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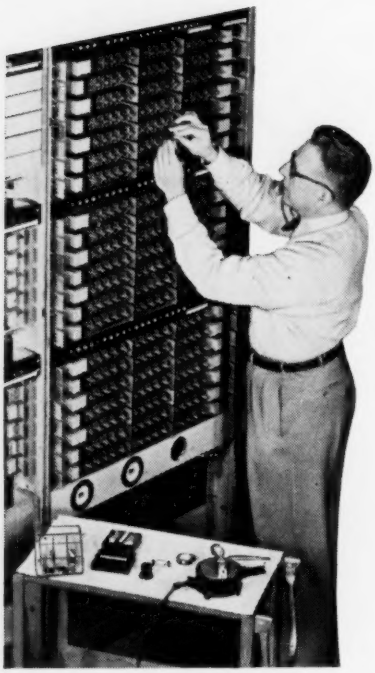


# *He's "fingerprinting" a relay contact*

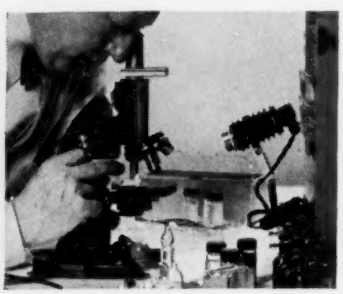
Bell Laboratories microchemists have perfected an ingenious new technique for "fingerprinting" relay contacts, the tiny switches on which a dial telephone system critically depends.

Using a portable test set, a chemist makes a plastic print of a contact. On-the-spot examination of the print with a microscope and chemical reagents quickly reveals the effects, if any, of arcing, friction, dust or corrosive vapors. While the chemist studies the print, urgently needed contacts continue in service. The findings point the way to improve relay performance.

This is another example of how Bell Telephone Laboratories research helps to keep your telephone system the world's best.

*Above,* Bell Laboratories microchemist applies plastic disc in heated clamp to relay contact. Imprint reveals contours of surface and picks up contaminants, if any. Part of portable test set is shown on table. Contacts, shown in small sketches, are of precious metal fused to base metal.

Preparing disc for microscopic examination. On-the-spot examination may reveal acid, alkali, sulfur, soot or other polluting agents peculiar to an area.



A microscopic look at disc often provides lead to nature of trouble. Unlike actual contact, print can be examined with transmitted light and high magnification.

Here the plastic disc has picked up microscopic lint that insulates contact, stops current. (Picture enlarged 200 times.) Traces of contaminants are identified in microgram quantities. Inert plastic resists test chemicals that would damage contact.

## *Bell Telephone Laboratories*

*Improving telephone service for America provides careers for creative men in scientific and technical fields*

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# Meetings

**August**

*1–5.* International Cong. of Plastic Surgery, Stockholm and Uppsala, Sweden. (J. F. Larsen, 12, Kristianiagade, Copenhagen, Denmark.)

*1–6.* International Cong. of Biochemistry, Brussels, Belgium. (C. Liebecq, 17 Place Delcour, Liége, Belgium.)

*3–7.* International Meeting of Neurobiologists, Groningen, Netherlands. (J. A. Kappers, Dept. of Anatomy and Embryology, Oostersingel 69, Groningen.)

*5–6.* Pennsylvania Acad. of Science, University Park, Pa. (K. Dearolf, Public Museum and Art Gallary, Reading, Pa.)

*6–7.* Linguistic Soc. of America, Washington, D.C. (A. A. Hill, 1719 Massachusetts Ave., NW, Washington, D.C.)

*8–10.* Inst. of Aeronautical Sciences, Seattle, Wash. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

*12–17.* Canadian Teachers' Federation, Ottawa. (G. G. Croskery, 444 MacLaren St., Ottawa, Ont.)

*15–16.* Operations Research Soc. of America, 7th national, Los Angeles, Calif. (R. A. Bailey, Military Operations Research Div., Lockheed Aircraft Corp., Burbank, Calif.)

*15–18.* American Veterinary Medical Assoc., Minneapolis, Minn. (J. G. Hardenbergh, 600 S. Michigan Ave., Chicago 5, Ill.)

*15–19.* American Inst. of Electrical Engineers, Pacific general, Butte, Mont. (N. S. Hibshem, AIEE, 33 W. 39 St., New York 18.)

*15–19.* American Soc. of Agronomy and the Soil Science Soc. of America, joint meeting, Davis, Calif. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

*15–20.* International Dental Federation, 43rd annual, Copenhagen, Denmark. (W. R. Klausen, 1 Alhambravey, Copenhagen V.)

*17–24.* Australian and New Zealand Assoc. for the Advancement of Science, 31st, Melbourne. (J. R. A. McMillan, 157 Gloucester St., Sydney.)

*19–28.* International Conf. of Agricultural Economists, Helsingfors, Finland. (J. R. Currie, Dartington Hall, Totnes, Devonshire, England.)

*19–30.* National Assoc. of Biology Teachers, Ann Arbor, Mich. (P. V. Webster, Bryan City Schools, Bryan, Ohio.)

*22–9.* Wool Textile Research Conf., Sydney, Australia. (F. G. Nicholls, Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne, Australia.)

*22–23.* Electronics and Automatic Production Symposium, San Francisco, Calif. (W. D. McGuigan, Stanford Research Inst., Palo Alto, Calif.)

*29–31.* American Physical Soc., Mexico City, Mexico. (K. K. Darrow, Columbia Univ., New York 27.)

*29–2.* Infrared Spectroscopy Inst., 6th annual, Nashville, Tenn. (N. Fuson, ISI, Fisk Univ., Nashville 8.)

*29–2.* International Assoc. for Hydraulic Research, 6th plenary, Delft, Netherlands. (L. G. Straub, St. Anthony Falls Hydraulic Lab., Minneapolis 14.)

*29–3.* Mathematical Assoc. of America, Ann Arbor, Mich. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

*29–5.* International Astronomical Union, Dublin, Ireland. (P. T. Oosterhoff, IAU, Leiden Observatory, Leiden, Netherlands.)

*29–6.* International Horticultural Cong., 14th, The Hague, Netherlands. (G. de Bakker, International Committee for Horticulture, Bezuidenhoutseweg 30, The Hague.)

*30–2.* American Mathematical Soc., 60th summer, Ann Arbor, Mich. (AMS, 80 Waterman St., Providence 6, R.I.)

*30–2.* Biological Photographic Assoc., Inc., 25th annual, Milwaukee, Wis. (L. C. Massopust, Sr., Marquette Univ. School of Medicine, 561 N. 15 St., Milwaukee 3.)

*31–2.* American Sociological Soc., Washington, D.C. (W. J. Warner, ASS, New York Univ., New York 3.)

*31–7.* British Assoc. for the Advancement of Science, annual, Bristol, England. (BAAS, Burlington House, London, W.1.)

**September**

*1.* Assoc. for Symbolic Logic, Ann Arbor, Mich. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

*2–7.* American Psychological Assoc., San Francisco, Calif. (F. H. Sanford, APA, 1333 16 St., NW, Washington 6.)

*2–7.* Psychometric Soc., San Francisco, Calif. (J. B. Carroll, Harvard Univ., 13 Kirkland St., Cambridge 38, Mass.)

*2–9.* International Cong. of Anthropological and Ethnological Sciences, 5th, Philadelphia, Pa. (A. Kidder, Univ. of Pennsylvania, Philadelphia, 4.)

*4–7.* International Congress of Vitamin E, 3rd, Venice, Italy. (K. E. Mason, Dept. of Anatomy, Univ. of Rochester School of Medicine and Dentistry, 260 Crittenden Blvd., Rochester 20, N.Y.)

*4–11.* International Cong. of Historical Sciences, 10th, Rome, Italy. (F. Chabod, X$^{e}$ Congres International des Sciences Historiques, Université, Rome.)

*5–6.* American Political Science Assoc., Boulder, Colo. (H. C. Mansfield, Dept. of Political Science, Ohio State Univ., Columbus.)

*5–8.* American Soc. for Pharmacology and Experimental Therapeutics, Iowa City, Iowa. (C. C. Pfeiffer, Dept. of Pharmacology, Emory Univ., Emory University, Ga.)

*5–9.* American Inst. of Biological Sciences, Michigan State University, East Lansing, Mich. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

*5–9.* Econometric Soc., Ann Arbor, Mich. (R. Ruggles, Box 1264, Yale Station, New Haven, Conn.)

*5–10.* World Cong. of Anaesthesiologists, Scheveningen, Netherlands. (W. A. Fentener van Vlissingen, WCA, Bilthoven, Netherlands.)

*6–11.* American Physiological Soc., Boston, Mass. (M. O. Lee, APS, 9650 Wisconsin Ave., Washington 14.)

*7–9.* American Soc. of Photogrammetry, Los Angeles, Calif. (C. E. Palmer, 1000 11 St., NW, Washington 1.)

*9–10.* Soc. of General Physiologists, Woods Hole, Mass. (J. B. Buck, NIH, Bethesda 14, Md.)

*10–15.* International Cong. on Cosmic Radiation, Mexico, D.F., Mexico. (H. A. Barton, IUPAP, 57 E. 55 St., New York 22.)

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THE
SCIENTIFIC MONTHLY

JULY 1955

# Human Background of Pacific Science

ALEXANDER SPOEHR

*Since 1953, Dr. Spoehr has been director of the Bernice P. Bishop Museum, Honolulu, Hawaii. He received his training in anthropology at the University of Chicago and, from 1940–1952, was a staff member of the department of anthropology at the Chicago Natural History Museum. The author is a specialist in ethnology and archeology, and his field work has taken him to the Marshall, Mariana, and Palau Island groups of Micronesia.*

THE scientific exploration of the Pacific can rightly be said to have begun the day that Captain Cook set sail from Plymouth in 1768 on his first voyage into the Pacific, with one of his major objectives the observation of the transit of Venus from a station to be set up on Tahiti. Captain Cook personified the scientific explorer, and his qualities of careful observation and sound planning were a forerunner of the work that was to follow.

Since Captain Cook's day, the islands of the Pacific have exerted a fascination that has repeatedly drawn men of science into this island world. The Pacific has well been called nature's greatest handiwork. It is true that much of Pacific science has been a matter of exploration, and it is only natural that the written product of Pacific science has in large measure been devoted purely to description and classification. Yet, at the same time, the Pacific has been the intellectual breeding ground of some of the major ideas of scientific thought. One need only mention Darwin and Wallace and the less well-known name of Gulick, whose observations on Hawaiian land snails led him to formulate ideas on speciation and variation that were a considerable contribution to biological thought at the end of the past century (*1*).

One reason for the attraction of the Pacific is that the region is peculiarly the home of phenomena that have exerted a continuing interest for men of science. Probably the best example is the question of the origin and development of coral reefs—those singular formations so prevalent in the Pacific which cannot fail to arouse wonderment in anyone who sees a coral atoll for the first time. The coral atoll is the subject of a fascinating chapter in the history of biology and geology, from the observations of Darwin, through those of Alexander Agassiz, to the postwar work of Ladd, Cloud, and their geologic colleagues as well as the broad series of investigations on the total ecology of coral atolls, sponsored in the last 5 years by the Pacific Science Board and supported by the Office of Naval Research (*2*).

Finally, as an anthropologist, I cannot refrain from mentioning that it was in the Pacific that the essential character of contemporary British and American anthropology first crystallized. The Cambridge University Expedition of 1898 to the Torres Straits, conducted principally by a zoologist, a linguist, two psychologists, and two medical men —there really were no professional field anthropologists in those days—was a landmark in anthropology. Since that time the discipline has demanded that its practitioners immerse themselves in protracted periods of field observation as part of their professional experience.

These are only a few facets of the development

A Marshallese girl from Majuro. [This photograph and the other illustrations are used through the courtesy of Raymond Sato, Honolulu Academy of Arts.]

of science in the Pacific. The background of this growth is provided by the people of the Pacific themselves. In the more than 2½ centuries since Captain Cook's day, great social changes have taken place in the Pacific. It is true that in the highlands of New Guinea and in a few isolated islands there are still communities relatively unacculturated and remote from concern with this troubled world. Yet most of the island peoples of Micronesia, Polynesia, and large parts of Melanesia —the area to which the following remarks principally apply—are caught up, just as we are caught up, in the complexities of a world society of which they are becoming increasingly aware.

It is the purpose of this paper (*3*) to examine briefly the human background of Pacific science—not of the scientists, who have a most interesting background themselves, but of the island peoples among whom they move. It is also the purpose of this paper to explore certain of the relationships of contemporary science to the changing Pacific scene.

The most obvious fact about the island peoples of the Pacific is that they all came as migrants. The Oceanic islands are neither a cradle of civilization nor a birthplace of the human race. For many centuries men have come to the islands of the Pacific and have changed the landscape of these islands by living upon them. But these men brought with them technologies already developed, systems of thought and ways of life already crystallized. It is germane to ask: What were the first migrants like and when did they come? At present it is impossible to give more than very tentative answers to these questions. They pertain to a historic problem whose solution is still before us. Yet at least the dimensions of the problem can be stated (*4*).

The last glacial period was characterized by a lowering of the sea level by some 150 to 200 feet because so much sea water became locked up in the great polar ice caps. At the height of the last glaciation, perhaps 15,000 to 20,000 years ago, New Guinea and Australia were a single continent, and only narrow stretches of water separated New Guinea from the islands of Indonesia. At this time man could have migrated from southeastern Asia across the Indonesian islands into New Guinea and Australia, largely by foot and needing only the simplest form of water transportation to make his way. It seems probable that at this time the earliest settlers of the Pacific followed this route into New Guinea and Australia. Among them seem to have been Negritos, or pygmy-blacks, who are found today in small isolated colonies in Australia, New Guinea, and the nearby Melanesian islands. At this time, too, there probably came the ancestors of the Australian aborigines, who appear to have interbred with Negritos. All these peoples possessed the simplest of technologies. They were food collectors and hunters and knew no agriculture. They had no knowledge of pottery or of other than the simplest crafts. They existed in small groups, living on game, fish, and edible plants.

A much later chapter is the settling of the islands of Micronesia and Polynesia. In order that this event could transpire two major preconditions were necessary. The first was the development of a form of water transport, and associated navigational techniques, sufficient to allow man to negotiate the great expanse of ocean that separates the Micronesian and Polynesian islands. The second was the ability to produce food as well as to collect it. The time of domestication of the principal Oceanic-southeast Asian food plants—particularly taro, yams, the banana, and breadfruit—is still not known, but they were an essential staff of life for settling the islands of Polynesia and Micronesia.

Possessing a developed form of water transport, carrying with them a distinctive biotic assemblage of cultivated plants and domestic animals, the Malayo-Polynesian-speaking peoples flowed out across the islands of Micronesia and Polynesia in one of the greatest periods of exploration and settlement the world has ever known. They occupied parts of Melanesia at an early date, although the history of that area remains clouded and uncertain. When these migrations commenced

is also uncertain. The earliest radiocarbon date from Micronesia is 1527 B.C. It seems probable that man first jumped off from the Malaysian area about 2000 B.C. on his eastward voyaging (*5*). The place of origin of the Polynesians and Micronesians is not yet known. Kon-Tiki notwithstanding, however, they came from the west, not the New World.

The last chapter in the history of Pacific migrations took place in modern times. It consisted of events whose outlines are well known. It followed upon another great period of exploration—that stemming from western Europe during the 16th, 17th, and 18th centuries. This last chapter includes the subsequent 19th- and 20th-century migration of Europeans, Americans, and Asiatic peoples into the Pacific islands. It includes the transformation of island life wrought by the extension of trade, the acceptance of new technologies, the development of towns and cities, the introduction of new ways of viewing the world.

These comments refer very briefly to three chapters in the history of human migration into the Pacific islands. In our present imperfect knowledge of prehistoric events in this area, there are other chapters that will one day be written but cannot be written now because of lack of information. Yet enough is known to pose some further questions. From the viewpoint of 1955, what kinds of societies exist in the Pacific today? Even at the risk of oversimplification, can one make general statements regarding their characteristics and how these came to be?

First of all, there are the very few urban centers of the Pacific islands, such as Honolulu and Auckland. Excluding Australia, these are urban but are not heavily industrialized. Those of us who live in Honolulu live in a city but not in an industrialized metropolis. These few cities are also young, for they are the products of the expansion of Western economy and of Western migration into the Pacific.

Second, there are the small port towns. These are more numerous than cities. They serve a neighboring area of plantations and an island hinterland. Papeete, Apia, Suva, Agaña, Nouméa, Port Moresby—names that are familiar to those with only a casual knowledge of the literature of the Pacific—are hardly cities, but they are focal points of culture change, for from them diffuse new ideas into surrounding areas. They attract people from the neighboring islands. They are small-scale centers for the extension of modern civilization, with all those gracious and ungracious ingredients that go into that way of life. No one has really looked closely at these towns, with the exception of James Michener of "South Pacific" fame. These towns are important because they serve an island hinterland. It is about the island hinterland that an anthropologist is most qualified to speak. It is to the island hinterland that I now turn.

Medical aid in the Marshall Islands.

The first point about the peoples of the Pacific hinterland is that, with the previously mentioned exception of New Guinea and some of the more remote islands, few indeed are the communities that have not been markedly affected by contact with the West. The isolated tribal society of the old days is largely a thing of the past. In this, my point can be made clearer by describing an example taken from my own experience. In general terms, I should like to describe briefly the people of the Marshall Islands, part of whose homeland has, since World War II, been converted into a testing ground for atomic weapons at Bikini and at Eniwetok (*6*).

The Marshal islanders live in small communities of a few hundred individuals each on the numerous atolls of the group. These communities exist primarily on food plants known since ancient times —taro, coconuts, breadfruit, bananas, pandanus— and on fish from the sea. Their technology has been considerably modified, but they are still close to the sea and make and sail their own canoes. In social life, kinship ties are of great importance and family relationships form a network that extends through the community. The pattern of land ownership and use is still strongly feudal, much as it once was in Hawaii. Magic continues to play an important role in concepts regarding disease and

(Left) Teacher training class at Majuro. (Right) A Ponapean family on its way to town.

in some forms of therapy. Relationships are personal rather than impersonal. Literacy is characteristic of a fair number, but only a minority exhibit superior competence, and it is an accomplishment carrying distinct prestige.

The contemporary culture of the Marshallese retains its essential Oceanic cast, but nevertheless it has been much modified during the century since traders and missionaries first established themselves in the atolls. Although the Marshallese still possess a largely subsistence economy, it is one that has been drawn firmly into the Pacific-wide copra trade. Exporting copra, the Marshallese import clothing, tools, flashlights, sewing machines, and other trade goods. These latter are an integral part of community life; they have long since ceased to be novelties.

Furthermore, the Marshallese are Christianized. It is true that many do not belong to the church, but there is no organized non-Christian religion surviving from ancient times.

Last, the old political organization is much modified through the nearly 70 years of political control by major powers—first Germany, then Japan, and now the United States. The political power of the chiefs is much on the decline, while that of the commoners is waxing daily.

Marshallese culture, therefore, is a blend, combining the influences of trader, missionary, and government official with ancient Oceanic tradition. Nothing could be further from the truth than considering these people as South Sea natives. To many Marshallese the term *native* is offensive, for it has all too often been used in a derogatory manner.

This is one society of Micronesia. Additional examples could be given from Micronesia, Polynesia, and parts of Melanesia that highlight certain common characteristics possessed by these societies of the Pacific island hinterland. These characteristics also have a dynamic aspect in that they are becoming accentuated and thus represent trends. The following, recognized by close observers of the Pacific scene, such as Felix Keesing and Raymond Firth, are among the most important (*7*).

1) All these communities are committed to the material civilization of modern industrial society. It is true that the degree of penetration of a money economy into the island hinterland is variable. It is also true that the very limited natural resources of the islands impose a ceiling above which economic expansion cannot rise. But almost everywhere there is some development of local enterprise. Everywhere there is an acceptance of, and desire to become incorporated into, an international commercial economy.

2) There has been an emergence of new status systems. In Polynesia and Micronesia there once prevailed a rigid class structure of chiefs and commoners. New bases of status are now emerging out of contact with the West. Increasing prestige and authority is accorded the medical aide, the local entrepreneur, the elected political leader, even the school teacher and the native pastor. Emerging forms of leadership are readily apparent. These emerging leaders will play a major role in the changes that lie ahead.

3) Last, and most important, is the way in which these island peoples are coming to view the world they live in. The tribal society is isolated as much in the close boundaries of its world-view as in the fact that it is economically tied to its habitat. The "world-view" of a people is the way they characteristically look outward upon other peoples and, indeed, upon the universe. The world-view of these societies today seldom encompasses only their own little group of islands. More and more it includes the margins of the Pacific as well. With some it includes the world and major problems of war and peace.

World War II was largely responsible for this change. Only a decade ago the tides of war flowed through Micronesia and parts of Melanesia, and Polynesia also felt its impact. It left behind, in the minds of the islanders, a widening of social horizons. It stimulated a growing political awareness of the world. It resulted in an increased sensitivity to the racial differences among men and to the problems of race relations. All these are facts of a changing world-view.

I have noted briefly some of the historical background of the contemporary Pacific scene and some of the characteristics of the various peoples that compose it. At what points and in what ways is this changing social scene related to the prosecution of scientific work in the Pacific island area?

As an observer, I am willing to venture that future events in the Pacific islands will increasingly revolve around a facet of life that forces itself more markedly into our consciousness with each passing day. This facet concerns the moral order that governs the bonds among men. The "moral order," to use a definition borrowed from Robert Redfield in a recent highly perceptive book (*8*).

> . . . refers to the organization of human sentiments into judgments as to what is right. . . . The word *values* is a related conception, but the phrase *moral order* points to the nature of the bonds among men, rather than to a category of the content of culture.

I have pointed to the expanding social horizons among the societies of the Pacific Island hinterland. This same expansion is also taking place among the urban communities. In the Pacific, and here we may include Indonesia and all the Far East as well, the transformation in world-view is crystallizing around the conflicts and difficulties in reconciling different ways of conceiving how the relationships of man to man and society to society are to be ordered. The present conflict between Communism and the democratic societies overshadows all else, but I am not thinking of this primarily. I am thinking of all the various island communities, the individuals of each of which are in greater or lesser degree finding their local aspirations involved with aspirations of other communities. The involvement can be seen at increasing levels of complexity, as communities are viewed in larger combinations. In this matter, I see a period of flux ahead and an increasing concern with the moral basis of human relations.

Science and scientists are involved in this growing concern with the moral order in at least two ways. The first is indirect. Every scientific field worker goes to the Pacific islands of Melanesia, Micronesia, and Polynesia very much as an alien in a foreign land. He is a representative of a foreign, though often politically dominant, society and as such is necessarily involved in the meeting of two cultures. To the extent that science is a principal theme of American life and because science cuts across national boundaries, the American scientist in the Pacific bears more than the ordinary responsibility of an American abroad.

Second, the examination of contrasting moral orders is susceptible to observation and comparison by at least one discipline that is represented in the American Association for the Advancement of Science—that of anthropology. Although this aspect of its work falls in the social, rather than the biological, sciences, it is a field of inquiry that can add much to the understanding of the tensions that will no doubt develop in the Pacific. This is not to imply that spiritual values should be slighted as a basis of our own conduct. It is rather that methods of scientific inquiry can be extended to the rational examination of the moral order of different societies and that this moral order is not outside the sphere of direct observation.

The differences between communities and societies cannot be resolved simply by a modern prophet's proposing that we all adopt the first principles of human conduct as adumbrated by himself. The difficulty with first principles is that I like mine, but you may not. Principles there assuredly must be. But let us first clearly understand them.

Scientific work is also related to the changing Pacific scene in a more direct way. This is evident in a growing attempt to apply the practical results of scientific research for the benefit of island peoples—in public health, in agriculture, and in promoting the general economic and social well-being of the islanders. The expanding program of the South Pacific Commission is a case in point. It should be noted that the Pacific islands lying in the vast area between Hawaii, New Zealand, Australia, Indonesia, and the Philippines are politically dependent and are, with the exception of the Kingdom of Tonga, administered by outside nations. On these nations the burden of prosecuting applied science falls.

This application of science has a number of interesting ramifications that go far beyond the confines of the Pacific. One example must suffice. Largely as a result of the introduction of public-health measures and of modern medical practice, the Pacific islands are passing from a phase of marked population decline to one of marked increase. The world-wide question of how the human

(Left) Boatworks at Ponape. (Right) Weighing copra in a Ponape warehouse for export.

species, increasing in numbers at an astronomical rate, is going to support itself in the future, can be observed in microcosm on a number of Pacific islands where population pressure on limited resources has already become acute. The great advantage of the Pacific for the observer is that it is insular, and that island communities are small enough so that a single observer can comprehend a given problem in all its phases. When such a problem, as that of population increase, is of world-wide significance, the value of Pacific studies is accordingly enhanced. In this same vein, I am often reminded of how closely knit man and nature seem to one who spends any length of time on a Pacific island. For studies of human ecology, there are few better fields of observation than the Pacific.

Before leaving the subject of the application of scientific research, I must mention one of its aspects of growing importance. Having followed rather closely the course of the American administration of the Trust Territory of the Pacific Islands, I have been struck with some of the difficulties inherent in the application of special knowledge in administrative practice. The Trust Territory has been the scene of much scientific research since the close of World War II. We now know a great deal more about these islands than has ever been known before, very largely through the sponsorship of field research by the Pacific Science Board and the active cooperation extended by the Administration—both Navy and Interior Departments—of the Trust Territory.

Now a scientific project reaches its culmination with the publication of the results. For the successful application of such knowledge, however, publication is only the beginning. A busy administrator has not the time, training, or inclination to select from a large body of published data, material of immediate relevance for a practical problem. If research has resulted in something that is easily understood and readily applied, the problem is not great. The application of special knowledge involving more complex data, particularly cultural data, however, is not easy, if for no other reason than that finding the relevant results of field research in the present welter of published material is a formidable task in itself. A major step forward has been the appointment of specialist advisers to the Administration. Whether scientifically trained advisers should in addition be incorporated into the organization as officers with direct administrative responsibility within their fields of competence remains an open question. In any case, the application of special knowledge is a problem in communication that the scientist who produces special knowledge has a responsibility to consider and to help solve. It is a problem that is not confined to Pacific dependencies; it also exists in many large-scale industrial and governmental organizations in other parts of the world.

A final comment on the relationship of science to the human background of the Pacific concerns the extent to which science as a manner of thought has penetrated into the communities of the Pacific. To what degree have certain characteristics associated with science—the cultivation of the inquiring mind, the ability to undergo the vigorous and protracted routine of making observations and collecting data, the respect for evidence, and the imaginative ability to frame significant problems and to see the interrelationship of observed facts—been diffused into the Pacific islands? It is true

that these habits exist in the common-sense practice of all people to some degree, but to what extent have they been accentuated?

Because the inner islands of the Pacific are political dependencies, these characteristics have diffused in conjunction with efforts by governments to extend applied science—in the training of medical aides, weather observers, school teachers, agricultural technicians, and the like. This extension of applied science has gone hand in hand with the extension of literacy. At the same time one cannot say that science as a profession really exists among these island peoples today, except as visiting scientists are domiciled among them.

When we leave this area and go to the margins of the Pacific, however, a different situation prevails. Everyone is familiar with the fact that science as a profession does exist as an integral part of life in Hawaii, New Zealand, Australia, and Japan. In the nations of Malaysia and southeast Asia, however, science is still in its youth, although recently implanted in the Philippines. These new nations—old as cultures, new as important international powers—the Philippines, Indonesia, Thailand in particular, exist in one of the critical areas of world affairs. They are participating with Asia in an inexorable move toward a greater international role.

In this connection, the meeting of the Eighth Pacific Science Congress in Manila in November 1953 was of particular note, for this congress, held in the capital city of a new Pacific nation, was attended by a large proportion of non-Caucasian participants. The worth of the congress may well have lain largely in this fact. I feel so because whether or not science will actually take hold and flourish in these new nations is a question of more than academic interest. Although the matter is perhaps open to dispute, I believe there is a more than fortuitous relationship between the growth of science and democracy.

The Pacific islands—Polynesia, Micronesia, Melanesia, together with the more complex area of Malaysia—form one of the most fascinating of regions. In Pacific science, the era of sheer description of the characteristics of this area is drawing to a close. Equipped with a sharper sense of problem, the scientific worker in the Pacific islands, whatever his discipline, is approaching his field of observation with fresh eyes. Space does not permit documenting this trend. It must suffice to state that there still exist a challenge and an opportunity for scientific field research in the Pacific. The Pacific is today America's western frontier. It remains largely for the scientist to delve below the superficial flow of events to discern the underlying processes that govern nature and man in this great region of the earth.

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*I know of no more encouraging fact than the unquestionable ability of man to elevate his life by a conscious endeavor.*—THOREAU.

# Some Scientific Aspects of the Urban Air Pollution Problem

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Los Angeles, which spends more for research and control of air pollution than any state or nation, has become the testing ground for similar problems in other cities.

The Los Angeles Basin is an area of approximately 1630 mi² enclosed on three sides by mountains; temperature inversion layers frequently hover over this area, often only about 1000 ft high; winds from the Pacific Ocean are usually gentle and variable, so that the polluted air moves slowly and becomes stagnated as it moves. Five million people live in the basin; they operate 2,361,000 motor vehicles. Currently, about 58,000 tons per day of natural gas, fuel oil, gasoline, and rubbish are burned imperfectly, emitting more than 3000 tons per day of potentially significant pollutants to the air. Nearly one-half of this amount, consisting largely of hydrocarbons and partially cracked or oxidized products, reportedly comes from the operation and fueling of motor vehicles. Rubbish disposal from 5 million people contributes perhaps 500 tons per day of pollution, not including carbon dioxide and water. These pollutants in the air drift slowly and are subjected to brilliant sunshine capable of energizing a variety of chemical reactions.

Table 1 illustrates the sort of readings obtained on bad smog days in Los Angeles in 1954 when the height of the inversion base was about 1000 ft.

Polluted air contains large numbers of invisible gaseous pollutants in addition to many kinds of particulate matter. The pollutants emitted into the air in any large city amount to thousands of tons per day. Concentrations in the atmosphere are at least three orders of magnitude below those usually encountered by scientists and engineers. Chemical reactions in the atmosphere call for close scrutiny; impurities in the air may include stable or transient reaction products of original pollutants, and substances that would usually react instantly may coexist at low concentrations in the atmosphere for long periods. Identification and measurement of these pollutants is the primary problem in any attempt to control and eliminate the noxious effects of air pollution.

### Analysis and Instrumentation

Automatic analyzers have been devised, which supply a 24-hr continuous record of the concentration of a single constituent or a group of related constituents of pollution.

Air pollutants can be divided into two principal groups: gases and aerosols. Gases include inorganic gases, such as sulfur dioxide, hydrogen fluoride, chlorine, and hydrogen sulfide; organic gases and vapors, such as ethylene, mercaptans, and the so-called "smog" gases, which are believed to include reaction products of various hydrocarbons or other organic compounds, and ozone, aldehydes, peroxides, and nitrogen oxides. Aerosols include liquid and solid particles, some of which have physiological interest because of their ability to enter human lungs in sufficient amounts to be extremely toxic.

*Analysis of gases.* Sulfur dioxide is one of the most widely distributed air pollutants, since it is produced in nearly all combustion processes. It is determined by methods that measure (i) its reducing properties, (ii) its acidity and electrolytic conductivity after oxidation to sulfuric acid, or (iii) its reaction with certain organic compounds to yield colored substances.

One recording method based on reducing properties of sulfur dioxide consists of absorbing the gas in an iodine solution and then back-titrating the excess iodine with thiosulfate. This method has great sensitivity for low concentrations, but it is limited in the handling of higher concentrations of the gas. Another recording method is embodied in the "titrilog" that oxidizes the absorbed gas with electrolytically produced bromine and records the current needed for the bromine liberation. This method is sensitive to 0.1 parts per million (ppm) of $SO_2$.

These recording methods are not specific for sulfur dioxide alone; other substances with oxidizing and reducing properties, such as hydrogen sulfide or oxidants, would influence the results. However, since the interferences of the two methods are different, in combination they should give correct $SO_2$ concentrations. Greater specificity in sulfur dioxide analyses might be obtained by colorimetric and polarographic procedures; however, these have not yet been developed as recording procedures.

Analysis of hydrogen fluoride is difficult because concentrations are often as small as 0.1 part per billion (ppb). Fluoride must be collected from large volumes of air; hence, the sampling period is prolonged for several hours. The determination is usually carried out by absorption in water or alkali followed by titration with thorium nitrate, generally after distillation. When it is properly carried out, this analysis gives accurate results but, at best, is laborious even though atomatic in the sample-collecting stage.

A new method (*1*) has been developed, based on absorption of the gas in a spot on a filter-paper strip impregnated with oxine, which fluoresces in near ultraviolet light. The hydrogen fluoride quenches the fluorescence, and the extent of this quenching is recorded. Sampling time is 15 min and sensitivity is 0.1 ppb.

Smog gases, including ozone, are said to be oxidizing substances that are formed by the action of sunlight on dilute vapors of organic compounds, such as hydrocarbons. These gases are analyzed with the continuous oxidant recorder developed by Littman and Benoliel (*2*) of Stanford Research Institute. In this method, the liberation of iodine from neutral buffered potassium iodide is measured colorimetrically and recorded. The reagent is oxidized quantitatively by ozone and to some extent by nitrogen dioxide and organic peroxyacids. Another similar instrument has been developed by Haagen-Smit (*3*); it uses reduced phenolphthalein instead of potassium iodide as the reagent. The same general pattern is shown by both reagents.

Nitrogen dioxide and nitric oxide are said to be involved in smog-forming photochemical reactions. Therefore, analytic methods for their determination have been developed. Samples are collected by use of the evacuated bottle, and complete absorption is obtained by shaking or rotating the bottle. The absorbing solution contains either hydrogen peroxide, which oxidizes all nitrogen oxides to nitrate, or an alkali solution or a mixture of sulfanilic acid and naphthylamine in dilute acetic acid (Griess reagent). In the former case, the nitrate is determined with phenoldisulfonic acid; in the latter, the alkaline solution must be neutralized and treated with the Griess reagent.

Nitrogen dioxide can also be quantitatively absorbed in a bubbler, using a fritted disk of medium porosity and an alkaline solution that foams adequately; or a spiral or tubing with 3-mm inside diameter about 10 m long in a 5-cm diameter coil placed horizontally can be used. Nitric oxide is not absorbed either in the bubblers or in the coil when its concentration is less than 1 ppm. If the absorption period is sufficiently long, it can probably be determined in the bottle method. There is an urgent need to compare the bottle methods with the bubbler and coil methods, since

Table 1. Typical observations during bad smog days in Los Angeles in 1954.

| | Range (pphm) |
|---|---|
| Oxidant* | 1–37 |
| Total hydrocarbons (as hexane) | 11–162 |
| Nitrogen oxides (as $NO_2$) | 5–61 |
| Aldehydes† | 22–70 |
| Carbon monoxide | 12–3300 |
| Visibility | 0.1–3.0 mi |
| Plant damage‡ | Up to 62 percent |
| Eye irritation§ | Up to 44 units |
| Total particulates | 43.5–105.2 $\mu g/m^3$ |

* By buffered KI; values reported are believed to be largely ozone.

† Measured by bisulfite reagent.

‡ Estimated damaged area on two bottom leaves of a selected strain of pinto bean grown under precisely controlled smog-free conditions and standardized for test purposes; scores of such plants used daily.

§ Arbitrary numerical scale where 5 is threshold, 25 moderate, and 35 severe; based on statistical evaluation of systematic subjective observations of panels of 20–30 regular observers at each of 10 stations distributed over the Los Angeles Basin.

it is possible that smog gases contain organic nitrites that could further complicate the analytic problem.

Photochemical reactions may cause innocuous compounds, such as hydrocarbons, to assume eye-irritating and phytotoxic aspects. It is necessary, therefore, to elucidate these reactions and to identify the compounds involved. Ultraviolet and infrared spectrophotometers are used to determine hydrocarbons and various organic functional groups.

To concentrate the pollutants for these instruments, cold traps at –78°C and –183°C are used. Both Stanford Research Institute and the Los Angeles County Air Pollution Control District are currently working with this method of hydrocarbon determination. Preliminary work shows the formation of aldehydes and peroxyacids, possibly also organic nitrites, from the irradiation of mixtures of hydrocarbons and nitrogen dioxide. Ozone was not found.

Aldehydes are determined by reaction with bisulfite or 2,4-dinitrophenyl hydrazine. This system could readily be set up as a continuous recording method. D. M. Coulson has developed a simple analysis of aldehydes and ketones with the polarograph, using semicarbazide as an absorbent. Formic acid may be a significant constituent of smog; it can be determined in the presence of other organic acids by reduction of formaldehyde and application of the chromotropic acid reaction.

*Analyses of aerosols.* Aerosols are responsible for reduced visibility where there is no fog; in addition, there may be a synergistic action between toxic gases and aerosols by which gases are absorbed on the particles and carried into the lungs.

Particle density in the air can be determined in several ways by light scattering. The transmissometer beams a powerful light through distances up to 1000 ft into a well-shielded photocell whose output is continuously recorded. Some instruments use forward scattered light to measure particle density; one of them, designed by Sinclair (*4*), is capable of recording particle density over a wide range because the scale of registration is logarithmic. The instrument incorporates a molecular filter so that particles can be observed under the microscope. Two other instruments—the thermal precipitator and the cascade impactor—deposit the aerosol on microscope slides for visual observation.

Recently, devices that filtrate particulate matter on filter paper or molecular membranes have caused much attention. Stains on the filter paper are analyzed by measuring reduction of reflected or transmitted light. The principal masking agent that causes reduction in reflectance or transmittance is carbon. Carbon appears to rise and fall with the general pollution level. In addition to measuring variations in pollution levels, some of the filter-paper samples are of sufficient size to permit spectroscopic analyses.

Large volume samplers have collected aerosols in sufficient quantities to make complete chemical and physical analyses. However, much labor and expense are involved in this method. Dust collections in air-conditioning systems have proved useful. Hemeon (*5*) reports that dust taken from an electric precipitation unit in a private home in Donora, Pennsylvania, showed that solids in the air contained about 30 percent zinc ammonium sulfate. This material probably contributed to the fatal smog effects by irritating the lungs. Similar collections in London indicate amounts of ammonium sulfate in the dust, sometimes as high as 20 percent.

There has been important progress in the field of analyses and instrumentation, but specific research should be directed along these lines: (i) for measurement and instrumentation, use of spectrometers, using microwave absorption spectra (this research is underway or projected); for identification of contaminants, use of methods based on paramagnetic and nuclear magnetic resonance; for continuous analysis of the lower atmosphere, adaptation of solar radiometry over a broad spectrum; (ii) elucidation of smog-forming reactions in order to discover their control; (iii) elucidation of present and proposed "wet" methods of analysis for atmospheric oxidants; and (iv) measurement, composition, and mechanism of formation of aerosols.

### Control of Atmospheric Pollution

The modern air pollution problem is in sharp contrast with traditional efforts at smoke abatement. Indeed, control methods in urban areas today must take into account the effect of the pollutant. Is it felt near a single source or experienced throughout the community? This effect is governed by the concentration and types of contaminants, and by the duration of fumigation. For this reason, the pollutants must be identified, sources of pollution must be evaluated through stack analyses, and, in addition, investigations should be made on the types of human activities that influence pollution levels. Progress is being made in all these fields of endeavor.

Planning for any control program must also take into account the capacity of local weather conditions to disperse or accumulate air pollutants. The dispersion of pollutants by air motion is a con-

tinuous process, but the rate at which this dispersion takes place is extremely variable and is determined by horizontal and vertical movements of the atmosphere. Wind velocity indicates the effectiveness of horizontal dispersion, and, in most areas, horizontal air movement is usually greater at increased heights above the ground. Vertical dispersion can be retarded by an abnormal vertical temperature distribution in the atmosphere, such as an inversion condition when there is an increase in temperature with height. Prolonged inversion conditions and a lack of horizontal movement permit an accumulation of air pollutants, which, in some cases, as at Donora in October 1948 and in London in 1952, have proved serious health hazards.

Control measures in cases where prolonged inversion conditions cause air pollution must be directed against all contaminants. For convenience, pollutants are classified in three categories: aerosols, vapors, and specific gaseous contaminants. The following are basic methods of control: (i) Reduction at the source by collection equipment. (ii) Dilution of the source by using sufficient air to render the discharge unobjectionable, as in tall stacks. (iii) Allocation of land to prevent harmful concentrations from occurring at a single source or from coming from an area with many sources. Either the acreage occupied or the total contaminants discharged can be regulated; activity in a given area will govern control measures here.

Equipment for the control of aerosols is based on some physical mechanism of entrainment separation. Principal collection equipment in this category is listed in Table 2; data in this table must

Table 2. Collection equipment—solid and liquid aerosols.

| Type | Dust characteristics | | | Pressure drop (in. of $H_2O$) | Advantages | Disadvantages | Percentage of efficiency (wt. basis) | Initial cost dol/ft³ min |
|---|---|---|---|---|---|---|---|---|
| | Type | Particle size (μ) | Specific gravity | | | | | |
| **Centrifugal collectors** | | | | | | | | |
| Simple cyclone | Wood dust | 50–1000 | 0.4–0.7 | 0.5–2.0 | Simple in construction | Low efficiency | 70–90 | 0.55–0.90 |
| | Grain dust | 10–200 | 0.9–1.1 | | | | 60–80 | |
| | Mineral dust | 10–500 | 2.0–3.0 | | | | 70–90 | |
| | Pulverized chemicals | 10–500 | 1.5–3.0 | | | | 70–90 | |
| High-efficiency cyclone | Catalyst dust | 2–80 | 1.5–3.5 | 2.0–6.0 | Relatively high efficiency | Subject to abrasion damage | 65–80 | |
| | Fly ash | 0.1–100 | 0.4–1.5 | | | | 50–70 | 0.75–1.10 |
| | Other fine dust | 5–200 | 1.0–3.0 | | | | 85–98 | |
| Impeller | Foundry dust | 10–300 | 2.5–4.0 | Acts as own fan | Low space requirement | Impeller abrasion, causing unbalance | 70–90 | 0.75–1.10 |
| **Electrostatic precipitators** | | | | | | | | |
| Single-stage | Gray iron Cupola fume | 0.5–50 | 3–6 | 0.25–0.5 | High efficiency under severe conditions | High initial cost, operating difficulties | 90–97 | 1.50–5 |
| | Electric steel Furnace fume | 0.1–20 | 5–7 | | | | 90–97 | |
| | Open-hearth steel* Furnace fume | 0.1–3 | 5–7 | | | | 96–99 | |
| | Catalyst dust | 2–80 | 1.5–3.5 | | | | 85–98 | |
| Two-stage | Oil mist | 10–400 | ~ 1 | .25–0.5 | High efficiency for low dust loading, safe in operation | Limited in use | 85–99 | 0.90–1.50 |
| | Air conditioning | 0.2–10 | | | | | 95–99 | |
| **Cloth filters** | | | | | | | | |
| Tubular | Metallurgical fume | | | 0.5–6.0 | High efficiency over wide particle-size range | Caking from moisture | | 0.80–2.50 |
| | Nonferrous | 0.13–1.0 | ~ 5 | | | | 98–99.5 | |
| | Ferrous | 0.10–50.0 | 3–6 | | | | 97–99.5 | |
| Screen or frame | Ceramic ducts | 1–50 | 1–3 | .5–4.0 | Somewhat self-cleaning | Higher stresses on filter mediums | 95–99.0 | 0.80–2.50 |
| | Metallurgical fume | 0.1–50 | 3–6 | | | | 94–97 | |
| Reverse flow (standard cloths) | Same as screen type shown above | | | .5–3.0 | Higher dust loadings possible | | | 1.00–2.50 |
| Reverse jet (felt mediums) | Carbon black | 0.1–10 | 1.5 | 1.0–6.0 | High filter ratios possible | Bag wear | 99.5 | 1.00–2 |
| | Flour dust | 5–100 | 1.9 | | | | 99.9 | |
| **Wet collectors** | | | | | | | | |
| Spray-chamber | Rock dust | 40–500 | 2–3 | 0.5–1.0 | Low pressure drop | High nozzle pressure required for good collection | 60–75 | 0.35–1.50 |
| | Asphalt mist | 10–400 | ~ 1 | | | | 70–80 | |
| | Acid mist | 20–500 | 1.1–1.3 | | | | 70–90 | |
| Inertial | Al and Mg Grinding dust | 50–1000 | 1.7–2.8 | 2.0–4.0 | No nozzle maintenance | Higher pressure drop | 80–95 | 0.50–1.50 |
| | Foundry dust | 10–300 | 2.5–4.0 | | | | 70–90 | |
| Centrifugal spray | Rock and sand Dust | 20–500 | 2–3 | 1.0–4.0 | Combined scrubbing and centrifugal action | Abrasion | 75–95 | 0.50–1.50 |
| | Acid and caustic mist | 20–500 | 1.1–1.3 | | | | 75–95 | |
| Venturi scrubber | Sulfuric acid Mist from concentrator | 2–10 | ~ 1.5 | 10.0–15.0 | High efficiency, low water rate | High power consumption | 85–95 | 1.50–5 |
| | Chemical fume | 0.1–50 | 1.5–3.5 | | | | 60–85 | |

* Cold metal furnaces.

be considered as representative and not all-inclusive; efficiency and cost figures give ranges of operation.

*Reduction at the source.* Centrifugal collectors are used to separate dust from the exhaust stream (Fig. 1). These collectors are low in initial cost and simple in construction, but they have low collection efficiencies for material of small-particle size. Electric precipitators are of two distinct types. The single-stage, or heavy-duty, equipment is a high-voltage device in which the charging and deposition of particles take place at the same time. This type is used for steel furnaces, gray iron cupolas, nonferrous primary smelting, cement manufacturing, catalyst dust recovery, sulfuric acids, and fly ash from coal burning. This precipitator has large-volume capacities and high collection efficiencies over a wide particle-size range.

The two-stage precipitator (Fig. 2) charges the particles in one section and collects them in a succeeding one. This equipment is limited to light-duty air cleaning but may be used for mists. Cloth filters are used for high-efficiency removal of solid aerosols of particle sizes smaller than 10 $\mu$. The temperature of the exhaust stream must be maintained below 500°F, and excessive humidity must be avoided. Wet collectors control dusts, mists, and fogs. The liquid medium increases the particle size of the aerosol to be removed. The liquid may be used to remove continuously collected material from impaction surfaces and to prevent reentrainment. Efficiencies are low for dust except in devices with high-energy input. These collectors serve well for soluble contaminants or in cases of high dust loadings where large-particle size is predominant.

Fig. 1. Centrifugal collector. Cyclone and multicyclones serving flour mills. [Courtesy Los Angeles Air Pollution Control District]

Control of gaseous pollutants and vapors presents a more complicated problem. Gaseous pollutants vary from a few pounds to tons of gaseous products; their concentrations at the source may range from a few parts per million to 100 percent. Sources vary as to type. Engineering evaluations have to be made for each separate installation. Equipment in use is listed in Table 3; however, no classification is made to show efficiency or cost of control, since applications vary so widely.

Careful attention to basic design of control equipment can greatly influence the reduction of pollutants. Time, temperature, and turbulence are the three main factors to balance for a given air to fuel ratio in furnace design, thus effecting complete combustion. Modification in furnace design, for instance can be effective in reducing the discharge of aerosols or smoke. However, the best engineering designs cannot overcome deficiencies of operators in maintaining and properly operating the equipment. Therefore, training programs for operators are essential to any control program.

*Dilution of the source.* Ground-level concentrations of gases downwind from a single source have been determined mathematically, and practice shows reasonable agreement with the experimental results, which demonstrate that air contaminants reach their maximum ground concentration at distances about 10 times the stack height. At this distance, concentrations vary inversely as the square of the chimney height. Thus, increasing the height of stacks or increasing the discharge temperature of gases can be effectively employed in areas not subject to prolonged inversion periods. Dilution of a concentrated source with additional air is also employed at times. Many odor problems and single-stack nuisances can be eliminated in this way. However, in extreme conditions, when predetermined threshold values have been approached, operations of the responsible source are shut down. Automatic recording equipment is necessary for this type of control.

*Land use.* City planning should take into account such nuisances as emission of pollutants from industrial sources and their potential effects on adjoining areas, weather conditions, and the degree of control that can be applied. Basically, an acceptable level of contamination should be deter-

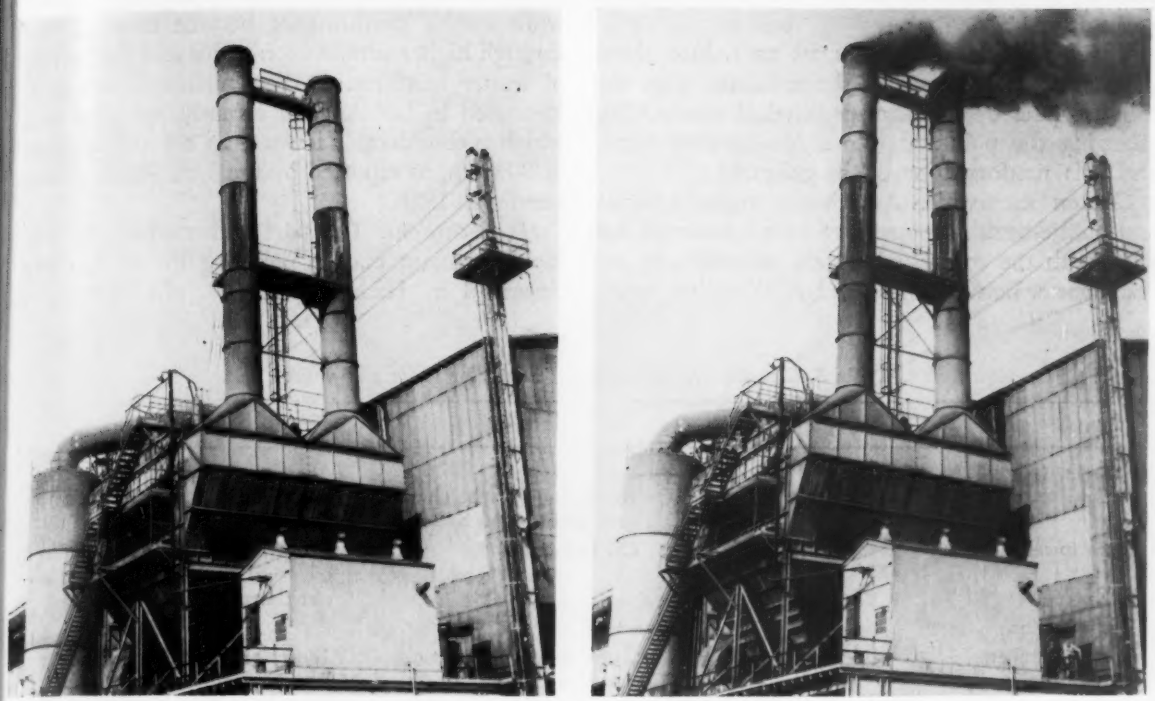

Fig. 2. Before and after operation of two-stage electric precipitator serving electric steel furnaces. [Courtesy Bethlehem-Pacific Steel Corporation]

mined. The land then should be occupied by a density of sources per acre to allow for acceptable concentration of pollution per acre. Studies of air currents, diffusion characteristics of the contaminants for specific conditions, and threshold tolerance levels can be developed to great benefit for all involved.

These are some of the methods in use at this time to combat noxious emissions into the atmosphere. However, much work is necessary to make these methods more effective. One method that we propose consists of large gas-chamber experiments with actual pollutants to determine physiological and other effects, to determine the relative importance of the more common pollutants, and to direct control efforts toward significant sources. Others might study inversion modifications and facilitate computations of wind trajectories.

### Combustion and Air Pollution

As our cities expand, more public and private transportation is needed in the form of motor vehicles and increased power requirements. This is the age of mechanization, and virtually all machines require power produced by a combustion process. Except for a very small amount of hydroelectric power, electricity is generated by the burning of coal, fuel oil, or gas. Our present combustion processes are all very imperfect and contribute by far the major part of man-made pollution. There is mounting evidence that organic compounds from combustion react in the presence of oxides of nitrogen and sunlight to produce oxidized organic compounds and ozone; that some of these organic oxygen complexes may be responsible for eye irritation, plant damage, reduced visibility, and bad odors. Improvement of combustion processes should be the first major goal of science and technology.

Vehicle combustion products are a major source of air pollution. Total motor-fuel consumption in the United States today is about 150 million tons per year; although the actual amount of air pollutants emitted by automobiles has never been accurately determined, it is calculated that 1 gal of gasoline produces 1000 $ft^3$ of exhaust gas on the dry basis. The constituents of this exhaust vary with the various phases of the engine-operating cycle. Table 4, prepared by the Los Angeles County Air Pollution Control District, gives values for constituents of auto exhaust.

The amounts of pollutants per 100,000 registered automobiles, based upon the estimated Los Angeles traffic pattern, are as follows (figures are for tons per day): carbon monoxide, 280; nitrogen oxides (as $NO_2$), 7.7; hydrocarbons, 44; sulfur

dioxide, 1.8; aldehydes, 1.8; lead, 0.05; oil droplets (aerosols), 1.3.

Three possible remedies exist to reduce these pollutants: (i) removal of the pollutant from the exhaust gases by chemical or physical means, (ii) changing the pollutant into a less noxious form, and (iii) nonformation of the pollutant.

*Carbon monoxide.* Automobile manufacturers and public-health groups have been concerned for years with the control of carbon monoxide in exhaust gases. Between 1930 and 1954, carbon monoxide emissions were reduced by about 50 percent, while engine performance became more efficient through higher compression ratios and the burning of leaner mixtures. Carbon monoxide values, as measured in Los Angeles recently, were 33 ppm, which is considerably lower than the average value of 80 ppm, as reported by the U.S. Public Health Service in 1928.

*Hydrocarbons.* The part hydrocarbons in automobile exhaust play in polluting the air has been described by Haagen-Smit (*6*). His experiments

Table 3. Classification of control devices for gases and vapors.

| Control method | Contaminants | Sources | Remarks |
|---|---|---|---|
| Absorbers (scrubbers) | | | |
| Packed towers | Malodors | Rendering plants, chemical plants, and so forth | Absorption solution: oxidizing agents |
| Plate towers | Hydrocarbons | Oil refineries | Absorption solution: absorption oil. (Oil is stripped and recirculated) |
| Spray towers | Acid gases | | |
| Spray chambers<br>Water jets | $H_2S$ | Thermal and catalytic cracking plants | Absorption solution: ethanolamines, potassium phosphate, Thylox, sodium phenolate, etc. (The solutions are regenerated.) |
| | $SO_2$ | Flue gases, chemical plants | Absorption solution: NaOH, $(NH_4)_2SO_3$-$NH_4HSO_3$, water, alkaline solution (Chemicals must be replenished.)<br>Dimethylamine (regenerated) |
| | $HNO_3$ | Chemical plants | Adsorption solution: alkaline solution |
| Incineration | | | |
| Flares | Hydrocarbons | Oil fields, refineries | Venturi burners or steam injection required for smokeless combustion |
| Fume burners | $H_2S$ | Oil refineries, chemical plants | $SO_2$ is product of combustion |
| | Malodors | Rendering plants, refineries, chemical plants, paint manufacturing, food processing, etc. | Temperature required: 900–1200°F |
| Catalytic combustion | Organic vapors | Litho and enameling ovens, rubber compounding, plastics, etc. | Catalysts: platinum, nickel; temperature required: 500°F |
| | CO, oil vapors, $NH_3$ | Catalytic cracking unit regenerators | |
| Adsorption | Organic solvents<br>Malodors | As above<br>As above | Mediums: activated charcoal, silica gel, activated alumina. Mediums regenerated by heat and stripping; disposal of liberated odors, etc., by incineration or other means |
| Vapor recovery systems | Gasoline, crude oil, and other volatiles | Storage tanks | Vapors may be compressed and liquefied or may be burned as fuel or flared |
| Floating roofs* | Gasoline, crude oil, and other volatiles | Storage tanks | |

* A floating roof is a cover on a vertical cylindrical type tank that rests on the surface of the liquid within the tank and moves as the level of the liquid changes.

show that hydrocarbons react photochemically with nitrogen dioxide to form an oxidant, presumably ozone. Intermediate or secondary products of this reaction may be responsible for some of the manifestations of Los Angeles smog, and therefore the Los Angeles County Air Pollution Control District has decided to control the emission of hydrocarbons from refineries and automobile exhaust.

The control of hydrocarbons in automobile exhaust is accomplished by their oxidation either by afterburners or catalytic converters. Afterburners must have a means of ignition and a means of adding auxiliary air or removing heat, and they must be highly efficient under widely varying conditions. Current models use a pilot light or a spark for ignition; this, however, has proved to be one of the difficulties of afterburners, since it represents a fire hazard.

The catalytic converter (Fig. 3) has the advantage of lower ignition temperature, no flame, and no need for hydrocarbon-air mixtures that support combustion of themselves. Disadvantages are deactivation of the catalyst by high localized temperatures; possible poisoning by lead, sulfur, barium, and other fuel and lubricating oil additives; and the necessary periodic reactivation of the catalyst.

A third method to eliminate hydrocarbons would be to prevent excess quantities of gasoline from reaching the cylinders, especially when adequate combustion cannot take place, such as in the deceleration cycle. Some type of fuel cutoff mechanism or the admission of heated air at atmospheric pressure to the cylinder may present solutions. A good fuel injection process would allow better control of oxidation reactions by limiting the time for preignition reactions.

Another method to eliminate hydrocarbons at the source is the use of alternate fuels, such as liquefied petroleum gas (LPG). This suggestion is based on the assumption that ozone-forming characteristics of hydrocarbons are limited to those of four carbon atoms or more per molecule. However, there are few data to prove the assumption that exhaust from LPG would be innocuous. In addition, there are economic problems involving expensive handling, availability of adequate quantities, and the probable need for dual fuel systems.

*Oxides of nitrogen.* Oxides of nitrogen are probably present as nitric oxide (NO) in automobile exhaust. Soon after entering the atmosphere, NO is undoubtedly oxidized to nitrogen dioxide ($NO_2$). In itself nitrogen dioxide is no particular hazard, but its contribution to air pollution is important if Haagen-Smit is correct. To decrease nitric oxide formation, the addition of a catalyst, such as iron oxide, has been suggested; another suggestion involves the addition of a material that, when added to either the fuel or the exhaust, would react rapidly with nitric oxide and render it harmless in the photochemical reaction.

Table 4. Results of a typical analysis of automobile exhaust gases.

| Gas | Idling | Acceleration | Cruising | Deceleration |
|---|---|---|---|---|
| Hydrocarbons ($C_3$–$C_9$), as hexane (ppm) | 1275 | 410 | 354 | 5125 |
| Acetylenic, as acetylene (ppm) | 825 | 18 | 64 | 687 |
| Oxides of Nitrogen, as $NO_2$ (ppm) | 8 | 4180 | 1606 | 18 |
| Lower aldehydes, as formaldehyde (ppm) | 88 | 1369 | 264 | 193 |
| CO (%) | 3.6 | 0.0 | 0.4 | 1.5 |
| $CO_2$ (%) | 10.0 | 13.7 | 12.9 | 6.1 |
| $O_2$ (%) | 1.4 | 1.3 | 1.1 | 9.5 |

*Sulfur dioxide.* The amount of sulfur dioxide emitted in automobile exhaust is comparatively unimportant.

*Aldehydes.* The exact contribution of aldehydes to air pollution is unknown. It is produced by auto exhaust, as is indicated by the acrid odor and the eye-burning felt when one is directly behind a large bus or truck. In Los Angeles the highest concentration of aldehydes was 0.7 ppm, a value much greater than can be calculated from known sources, which is 0.1 ppm. This can be explained by the Haagen-Smit theory of photochemical oxidation of hydrocarbons in the air to aldehydes. The same remedial measures for the removal of hydrocarbons are applicable to aldehyde elimination.

*Aerosols and oil droplets.* Oil consumption contributes to smoke in the atmosphere, and there is also evidence that part of the gasoline hydrocarbons polymerize and condense to form aerosol particles. Estimates of the amount of lubricating oil that enters the atmosphere daily via auto exhaust vary from 20 tons per day to 80 tons per day for the basin. Good automobile maintenance will reduce the output of oil droplets; aerosols from gasoline polymerization require control of hydrocarbon emissions from both the crankcase breather and exhaust pipes.

*Lead and other inorganic materials.* Current data indicate that lead concentrations in the atmosphere are not hazardous to health. The accepted value for industrial exposure to lead is 150 $\mu g/m^3$ (7). It is possible, however, that solid particles of lead and other inorganic compounds may act catalytically to produce noxious products from the various pollutants in the atmosphere.

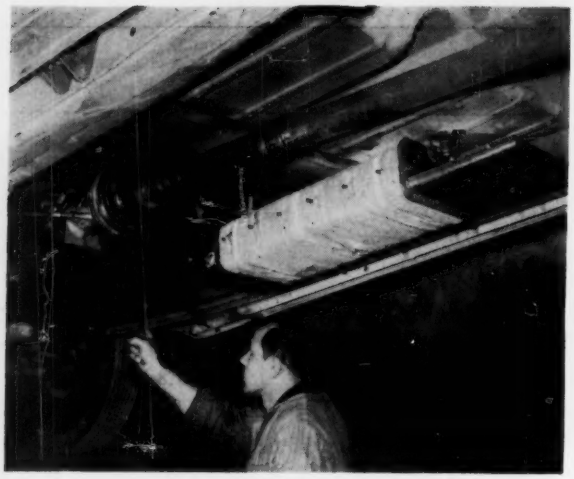

Fig. 3. Catalytic converter for white gasoline. [Courtesy Southwest Research Institute]

In general, combustion processes should be studied with a view toward improvement of all phases, and continued development of closed systems for chemical manufacture, such as petroleum refining, gas production, and other processes, should proceed.

### Physiological Effects

Physiological effects in the human body of continued exposure to air pollution are still largely unknown. Some preliminary epidemiological studies are being made to see whether any correlation is possible between morbidity data and the very limited data on concentrations of a few known pollutants. The problem is most complex, and years of painstaking research will be required, in the opinion of many physicians and public-health officials, before any valid conclusions can be reached.

Much attention has been given to the fact that lung cancer has been on the increase in recent years, especially in cities. Benzpyrene has been found in minute traces in cigarette smoke and in auto exhaust and other combustion products in our atmosphere; benzpyrene is a carcinogen for certain small animals, which opens the way for speculation on whether benzpyrene itself or other carcinogens present in our urban atmosphere could initiate lung cancer. Other physiological effects include irritation of the eyes and respiratory tract, noxious odors and tastes, and reduced visibility, all of which combine to form marked discomfort for all of us.

The Meuse Valley, London, and Donora disasters still defy interpretation. Observed concentrations of pollutants were far below the levels at which any harmful effects would be expected, leaving the implication that either the known pollutants in combination have a remarkably adverse synergistic effect or that the critical pollutants were not measured and are still unknown.

Man-made pollutants load the air in increasing quantities; their safe disposal poses many problems that can be solved only after the extent of their effects on man's health has been further recognized. Most of the available data in this field come from industrial toxicology, studies of catastrophes, and analyses of routine morbidity and mortality records.

Industrial toxicology serves to protect the individual worker in the plant. He is exposed to concentrations far greater than are ever observed in urban atmospheres, and, for this reason, such values cannot be readily translated to community problems.

The catastrophic smog incidents, such as Donora and London, represent extremes in concentration, and, therefore, information derived from such studies is limited in application.

Analyses of morbidity and mortality rates in areas of low and high pollution have definite deficiencies. They do not assume uncontrolled factors, such as age, race, and socioeconomic status, all of which should be taken into account in any study of the effects of air pollutants on human beings. Statistical studies of population using epidemiological techniques supply an accepted method today for a rounded attack on the problem. Great difficulties have been encountered in setting up indices and approaches for such a study. To date no entirely satisfactory study has been designed.

At the University of Cincinnati College of Medicine, a recent investigation described air contaminants and their relative concentration in Cincinnati by analyses of samples collected monthly for 5 years at 18 scattered stations. A project was undertaken to determine whether practical investigations could be designed to permit descriptions of the incidence, prevalence, and prognosis of disease in a population exposed to varying concentrations of air pollutants. Since the average worker showed resistance to exposure to relatively high concentrations, it was decided to utilize the reactions of unusually sensitive persons, those with chronic cardiac or respiratory diseases. Such individuals are more stationary, thereby diminishing the error of extrapolating environmental measurements. The present goal of this pilot study is the following hypothesis: Fluctuations in air pollution, as measured by soiling of filter paper, are negatively correlated with variations in the patients' well-being as assessed subjec-

Table 5. Age sex, and nature of disability of 33 patients composing the study group.

| Age (yr) | Nature of Disability | | | | | |
|---|---|---|---|---|---|---|
| | Cardiac | | Chest | | Cardiac and chest | |
| | M | F | M | F | M | F |
| 50–54 | 1 | 2 | 1 | 0 | 0 | 1 |
| 55–59 | 4 | 1 | 0 | 2 | 1 | 1 |
| 60–64 | 0 | 2 | 1 | 0 | 0 | 0 |
| 65–69 | 4 | 3 | 0 | 0 | 0 | 0 |
| 70–74 | 1 | 0 | 0 | 1 | 0 | 0 |
| 75–79 | 1 | 0 | 0 | 0 | 1 | 1 |
| 80–84 | 2 | 0 | 1 | 0 | 0 | 0 |
| 85–89 | 0 | 0 | 1 | 0 | 0 | 0 |
| Total | 13 | 8 | 4 | 3 | 2 | 3 |

tively by diaries and questionnaires and objectively by instrumental methods. Table 5 describes the patients used in this study; most of them were cardiac cases, and they proved to be affected as much by exposure to air pollution as were the chest cases.

In this experimental study, variation in the patients' conditions was of prime concern. Subjective reactions were recorded by the patients, and trained nurses regularly made objective measurements of lung function. There is a need for simple portable tests that can be used in epidemiological field studies of air pollution.

The following measurements were made of the patients' environment. (i) Pollutants were measured by the A.I.S.I. automatic smoke sampler. (ii) Temperature and humidity were recorded by an 8-day automatic thermohygrograph. In addition, four Wilson sequence samplers measured the extent of correlation between $SO_2$ (or total acid) and the concentration of smoke in selected locations. These observations will be adjusted for other measurements made by the Weather Bureau, the Bureau of Smoke Inspection, and the Sanitary Engineering Center of the U.S. Public Health Service. IBM equipment will be used to prepare tabulations.

The approach taken in this study is one of many possible attempts to show that human disease can be related to community air pollution, thereby elucidating physiological aspects of the problem. Other and more general research in this category might include epidemiological studies to assess physiological effects of urban air pollution and toxicological studies of known pollutants in experienced concentrations and combinations.

*Economic loss.* In addition to the physiological effects of air pollution—the discomforts and even fatal incidences associated with atmospheric contamination—we must remember its economic effects. Extensive damage is caused by air pollution in terms of deterioration and soiling of materials, damage to crops and vegetation (crop damage in the Los Angeles Basin is currently estimated at several million dollars per year), and poor combustion. (It is estimated that 7 percent of the gasoline put in an automobile fuel tank is discharged unburned. This would represent an economic loss of about $40 million for the Los Angeles Basin. For the county at large, it would amount to $1 billion.) The financial advantages of curtailing some of the known causes of air pollution alone would justify a much more vigorous attack on the problem.

### Plant Damage

Plants are seriously damaged during periods of aggravated air pollution. Many crops and weeds suffer silvering, bronzing, and necrosis of the lower leaf surfaces. Current annual loss in Los Angeles County alone was more than $3 million in 1953. However, the entire Southern California area is affected in progressive stages, as is shown in Fig. 4. In 1950 Middleton observed similar damage in the San Francisco Bay area, with further damage and economic loss reported in coastal central California.

The toxicants that cause this plant damage are the reaction products from the oxidation of hydrocarbons in refined petroleum and oxidants, such as ozone and oxides of nitrogen, in sunlight (*8*). The Citrus Experiment Station at Riverside, California, is currently investigating the effects of air pollution on plants and methods of protecting them and is

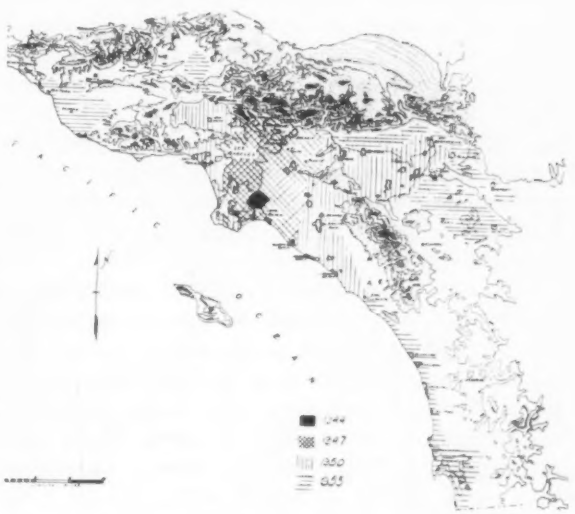

Fig. 4. Topographic map of the southern coastal basin of California showing areas progressively affected by plant damage. [Courtesy Citrus Experiment Station]

also studying the nature of the phytotoxicants by means of the plants' responses.

Plants vary in their susceptibility to the reaction products from the oxidation of hydrocarbons. Among the more sensitive species are alfalfa, sugar beet, bean, celery, and spinach; examples of resistant plants are barley, cabbage, muskmelon, pea, and tomato. The response of these plants to the new class of toxicants known as oxidants is distinctly different from that attributable to fluorides, sulfur dioxide, and the halogens.

In a controlled laboratory experiment, the susceptibility of various plants to the reaction products from the oxidation of hydrocarbons is measured. Extent of plant injury is measured by the percentage of leaf area damaged, and values are assigned from 0 to 10, representing no injury and complete damage, respectively. The pinto bean plant has been selected as a test plant, and it has been shown that the young immature leaves of the plant are not as susceptible to air pollutants as are the mature leaves; primary leaves are uniformly susceptible 2 weeks after emergence and for at least three additional weeks. Preliminary experiments also show that bean plants are more susceptible to damage when they are adequately watered. Possibly, protection can be afforded by withholding water from plants during periods of expected pollution damage. It was also noted that severity of plant damage increases with air temperature and that the application of nitrogen to the soil produces higher crop damage.

In addition to plant injury, it has been discovered that real damage may occur in the form of material retardation of growth in many plants. This is difficult to gage, since all plants in a given area may be subjected to sublethal dosages of toxicants, leaving no healthy plants for comparison. Growth suppression has been experimentally induced in alfalfa, endive, lettuce, oat, sugar beet, and tomato by exposure to ozonated gasoline. The possible effects of such exposure to the reaction products of oxidized hydrocarbons on growth retardation in citrus fruit are the subject of a current study.

Exposure of plants to oxidized hydrocarbons shows progressive damage. At first, a decrease of the permeability of the plant cells to inward and outward movement of water and radioactive phosphorus is noted, and then, after longer exposures, an increase of permeability is noted. These facts may explain growth suppresion effects, which may be a result of the decreased ability of the plant cells to absorb water and nutrients; and the necrosis of the leaves exposed to heavy doses, which may destroy the plants' ability to retain water and results in development of silver and bronze symptoms. These effects are under study by staff members of the Citrus Experiment Station, Riverside. Severity of plant damage varies proportionally to the time of exposure and the concentrations of pollutants. Plant damage has been reproduced in the laboratory using ozone and hexene and also using ozone alone. Yet, in spite of the fact that Los Angeles and San Francisco atmospheres allegedly have large ozone concentrations, no crop damage from ozone alone has been observed. A plant damage survey conducted in cooperation with the Air Pollution Foundation in the summer of 1954 supports these observations.

Some methods have been devised to protect plants from effects of air pollution. Topical application of aqueous suspensions of a number of bisdithicarbamates afforded such protection. This discovery gives further support to the concept that the principal toxicants are oxidants. Further investigations will perhaps provide better information to protect field-grown crops; glasshouse-grown crops can be protected from damage by passing the air through activated carbon filters. The response of plants to specific air pollutants can be used to determine the presence of such pollutants in the atmosphere.

Specific symptoms incited by exposure to oxidants can be used to determine the presence of ozonated olefins and ozone in polluted air masses. This response provides an excellent bioassay system for determining areas affected by pollution. Not only are areas clearly delineated, but the plant provides a specific response to two kinds of oxidants that cannot be readily separated by the usual chemical monitoring systems. Techniques can be developed to test plants, thereby devising a practicable means of determining the distribution and constitution of air pollution.

*Social responsibility of scientist and engineer.* When confronted with this broad new field of research, so many aspects of which have significant economic and social implications, the scientist and engineer have a deep-seated responsibility to deal with the unwelcome by-products of their inventions.

The concentration of machines in factories evolving new processes and products is responsible for nuisance pollution and even hazard-carrying pollution, which must be stopped if urban civilization is to keep on growing. Surely, the same technologic genius that brought forth these sources of pollution can contrive the cures.

Much preparatory work still must be done before adequate remedies for our pollution problem can be prescribed. We must analyze the air to identify the pollutants and their sources and to under-

stand the changes that take place in the air. We must equip ourselves for this research. The work done to date has only indicated the magnitude of the problem ahead of us. After we familiarize ourselves with the air around us, we must invent practical remedies to combat pollution. In the absence of these, legislation can do little toward the improvement of pollution conditions.

*Specific research needed.* Here are 15 suggestions for research projects that are urgently needed: (i) coordination and centralization of all knowledge of air pollution so that all cities may have access to it; this center might well be an activity in which professional societies could assist the Federal Government; (ii) development of adequate methods of measurement and instrumentation; research is under way or projected with spectrometers, using microwave absorption spectra, based on paramagnetic and nuclear magnetic resonance for identification of contaminants, adapting solar radiometry over broad spectrum to continuous analysis of the lower atmosphere; (iii) measurement of carbon isotopes in the atmosphere to determine the contribution of fossil versus nonfossil carbon compounds; (iv) elucidation of smog-forming reactions in order to discover how to control them; (v) elucidation of present and proposed "wet" methods of analysis for atmospheric oxidants; (vi) measurement, composition, and mechanism of formation of aerosols; (vii) large gas-chamber experiments with actual pollutants to determine physiological and other effects, to determine the relative importance of the more common pollutants, and to direct control efforts toward most significant sources; (viii) development of machine methods to compute wind trajectories; (ix) inversion modification studies; (x) improvement of combustion processes; (xi) continued development of closed systems for chemical manufacture, such as petroleum refining, gas production, and other processes; (xii) epidemiological studies to assess physiological effects of urban air pollution; (xiii) toxicological studies of known pollutants in experienced concentrations and combinations; (xiv) development of plant-testing techniques as a practicable means of monitoring air pollution; (xv) identification of phytotoxicants; studies of effects and remedies.

These examples are only a few of those that beg help from science and engineering and support from industry, the public, and government. This should not suggest that a solution is impossible. The record of scientific achievement in other fields promises that air pollution, too, can be resolved.

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*There are in science immense numbers of different methods, appropriate to different classes of problems; but over and above them all, there is something not easily definable, which may be called the method of science. It was formerly customary to identify this with the inductive method, and to associate it with the name of Bacon. But the true inductive method was not discovered by Bacon, and the true method of science is something which includes deduction as much as induction, logic and mathematics as much as botany and geology.*—BERTRAND RUSSELL, *Mysticism and Logic* (1918).

# Significant Scientific Discoveries by Medical Students

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At a time when educators are being asked to produce more researchers in the medical sciences, it might be useful to review the genesis of researchers in the past, in order to see to what degree they were "produced" and to what degree they were born investigators. This paper deals with only one fragment of that subject, the contributions to scientific medicine made by undergraduates. Of the 100 or so individuals, now dead, whom I have studied in this connection, I will mention only a limited number, trying, nevertheless, to give a representative sample of men known beyond the narrow confines of medicine.

The field of chemistry contains a number of student discoverers. Joseph Black, as a medical student at Edinburgh, was intrigued by the fact that two of his teachers, Alston and Whytt, disagreed on the most effective treatment for kidney stones. He approached the professor of medicine, William Cullen, an able chemist, with a plan for the investigation of the nature of kidney stones and thus the relevance or otherwise of the lime-water treatment that was often prescribed.

Cullen welcomed Black into his laboratory, as he did all inquiring young students. It was while he was at work there in 1752 that Black discovered that magnesia alba, when it was heated, lost "a remarkable proportion of its weight in the fire." He gave up kidney stones and went in search of the "volatile part," which he eventually named "fixed air." He wrote in his student thesis of 1754 that this "fixed air" was "dispersed through the atmosphere either in the shape of an exceedingly subtle powder, or more probably in that of an elastic fluid." It is not surprising that Black, the student-discoverer of carbon dioxide and father of quantitative chemical analysis, should go on to discover the properties known as *latent heat* and *specific heat*.

Black numbered among his students James Watt, of steam-engine fame, and Oliver Goldsmith, the poet, but most important, Daniel Rutherford, who reported his discovery of nitrogen in his graduation thesis in medicine in 1772 at Edinburgh. Black had set him the problem of what remained in the atmosphere after combustion and after the "fixed air" had been removed.

Of particular interest is the career of that restless mind, James Blake, characterized as the "Gold Rush Doc" by Chauncey Leake. He was California's first scientist of note, but his student contributions, at the age of 23, eclipsed any later efforts. While he was studying medicine at University College, London, he read a paper before the British Association for the Advancement of Science in which he advanced the theory, based on his own experiments, that the effect of drugs on the body is determined by their chemical structure. He showed that the electronegative elements could be arranged in order of their physiological reactions, and his grouping of the elements, which he tested on animals, was remarkably similar to the arrangement that was developed 20 years later by Mendelyeev and is now known as the *periodic table*. Blake's view was that the monovalent elements acted specifically on the lungs, the divalent on the heart, and the higher valences on the central nervous system.

One preeminent discoverer in this field was Sir Frederick Gowland Hopkins (1861–1947). He began life as a clerk in an insurance office. Forsaking this dreary job, he became an assistant in a commercial analytic laboratory. He had the good fortune to hear two or three lectures in chemistry

at the Royal School of Mines; later he said that these were "the only lectures on chemistry to which I have ever listened." Through University College, London, he prepared himself for examinations at the Institute of Chemistry and was offered work in a medicolegal laboratory at Guy's Hospital. While he was studying medicine in the hospital's medical school, he tried to "keep some sort of research going." His research was on the pigments of the English brimstone butterfly; he showed that these pigments are uric acid derivatives. This was the starting point for much of Hopkins' future research on nitrogenous compounds. Typically, he perfected an improved method for estimating uric acid, and with this key he subsequently unlocked many doors.

When later, as a medical graduate, Hopkins became interested in the role of proteins in nutrition, he turned for help to his early method of determining uric acid excretion. Then he went on to experiments involving purified proteins in artificial diets and, eventually, to a study of the deficiency diseases that he had produced by such synthetic diets. He postulated the existence of chemical substances that he called "unidentified accessory food factors"; today, we call these substances *vitamins*. Thus one inquiring mind, starting as a bottle-washer, became a Nobel laureate.

In the field of anesthesia, medical students have played the discoverer's role. Ether was first synthesized by the student Valerius Cordus, about 1540, in his uncle's apothecary shop in Leipzig. He knew of its properties in treating a "dry, hacking cough," of its volatility and great solvent powers, but the only suggestion of its possible anesthetic powers comes from Paracelsus, who had observed that chickens would consume it and would then sleep for hours and awake unharmed.

The incomparable Humphry Davy discovered the anesthetic properties of nitrous oxide as a 21-year-old Cornish-born medical student working with Thomas Beddoes at the Pneumatic Institution in Bristol. He wrote, in 1800, in his *Researches*:

> As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place.

Unfortunately he wrote this on the 556th page of his book and not on the first page.

As word of Davy's anesthetic discovery spread across the Atlantic, by such circuitous routes as the writings of the poet Robert Southey, who was one of Davy's voluntary assistants, nitrous oxide gained currency in "medicine man" shows, as ether did at social gatherings for the guests' amusement. A student, William E. Clarke, of Rochester, New York, was given to ether entertainments and, following his graduation from Berkshire Medical College, administered ether to a woman in January 1842 while a dentist painlessly removed a tooth. About the same time a young dentist, W. T. G. Morton, became so interested in anesthesia that he entered Harvard Medical School in order to qualify as a physician. While there he experimented with ether on a puppy, goldfish, insects, caterpillars, and even worms! The puppy broke a glass jar that was being used, and Morton soaked up the remaining ether with his handkerchief. He felt, after holding it to his nostrils, that this substance might suffice for dental anesthesia in place of the more hazardous nitrous oxide. After trying it on two dental students, Morton administered it to a patient on 30 September 1846 for a dental extraction. Two weeks later ether was used for the first time in major surgery in the clinic of John Collins Warren at Massachusetts General Hospital, Boston.

The field of physics contains many undergraduate contributors, of whom only two will be mentioned here—Einthoven and Thomas Young. Willem Einthoven, the son of a doctor, was born in Java in 1859. His father's early death made a medical career for the son unlikely until the Dutch Colonial government granted Willem a scholarship at Utrecht. In his first year he distinguished himself with an excellent student paper on the articulations of the elbow joint and on the mechanism of pronation and supination. Einthoven fell under the influence of Donders and Snellen in the clinics and wrote, as his graduation thesis, at the age of 25, a highly important paper on a subject of particular interest to us today, "Stereoscopic vision through color differences." Before graduation even, Einthoven was made professor of physiology in Utrecht. His fame lies, of course, in his introduction into medicine of the electrocardiograph, which is used in every hospital in the world today in the study of heart disease. He is one man who, happily, lived to see his invention recognized and used during his lifetime. He early saw the principle for his recording device in a comparatively crude submarine signaling device and, by making it 100,000 times more sensitive, he applied it to an analysis of the action of the diseased heart. He was awarded the Nobel prize in 1924.

Thomas Young, known as "Phenomenal Young," is remembered chiefly for his theory of light and of color vision and for Young's modulus of elasticity, which is used daily in engineering. Yet, the investigation that he made on the lens of the eye remains

a monument to a medical student, aged 20. For this work he was elected a fellow of the Royal Society of London at age 21.

Young had come up to St. Bartholomew's Hospital Medical School from his Quaker home in Somerset, full of ancient languages, the calculus, botany, meteorology, and lens grinding. He had scarcely begun his anatomy course when he was invited to dissect a very recently removed ox eye. The ciliary muscles responded to stimulation, thereby compressing the lens and changing its shape. At once Young saw that the alleged lengthening and shortening of the eyeball to accommodate for distance was a myth. Before long Young set out for Edinburgh to join Joseph Black. Within a year he went to Göttingen, where he graduated as doctor of medicine in 1795. His thesis, on the human voice, was remarkable for a 47-character alphabet that he had designed. Young's "universal alphabet" was to permit, by its combinations, the rendering of every sound expressible by the human voice.

From this graduation thesis of a 22-year-old medical student came a development, truly Newtonian in its import. Young's work on the combinations of sounds, and especially on the propagation of sound, led him into experiments in the analogous field of light. His wave theory of light and his theory of accommodation in vision were only two of his contributions made as a result of his investigations during his medical-student days. In addition, he became a pioneer in the study of the tides, in the construction of life-expectancy tables, in the measurement of "ultimate particles," or atoms, and finally in the deciphering of "the Rosetta Stone."

In physiology, Claude Bernard and Walter B. Cannon come to mind as student contributors to science. Claude Bernard, the father of experimental medicine, investigated, during his undergraduate years, two problems that were to determine his future career. These were (i) the secretory nerves to the salivary glands, and (ii) the digestive function of the gastric juice. (It is of note that the salivary glands were discovered by a Danish medical student, Nicolas Stensen.)

Bernard, like Lavoisier, was at first a playwright, but on coming to Paris from the Rhone, he tried to finance a medical career by instructing in a little experimental laboratory to which he hoped students would flock. Then, as now, most students were keener on cramming than observing, so Bernard had to turn his mind to tutoring for self-support.

His first paper on the distribution of the secretory nerve known as the *chorda tympani* was stimulated by a case of facial nerve paralysis, which he had seen on the wards. For his graduation thesis Bernard chose the subject of the digestive properties of gastric juice. His interest in digestion had already been stimulated by his work on the salivary glands, and now he modestly set out to study the digestion of carbohydrates, fats, and proteins! His work never progressed beyond the carbohydrate stage of this broad plan conceived while a student, and carbohydrate metabolism became his absorbing interest for the remainder of his life. His student thesis shows the uncanny way in which Bernard could wring the most out of his experiments. He first found that sucrose injected into the blood stream appeared later in the urine unchanged. However, sucrose that had been acted on by gastric juice and then injected intravenously appeared in the urine completely changed. His friend Barreswill, a chemist, perfected the cupric sulfate method of detecting glucose, and with this Bernard pursued his study further.

As a student Bernard also investigated the cherry-red color of blood that he had observed in carbon monoxide poisoning. It was not until 15 years later that he was able to find time to complete the work by developing a method for measuring the available oxygen in blood samples. This work, in turn, led him and his pupil Paul Bert into the field of respiratory physiology and especially the oxygen-hemoglobin relationships in the red blood corpuscles.

Claude Bernard's life as an early animal investigator was not easy. His gastric juice studies on a dog belonging to the local police commissioner almost brought an end to his career. However, Bernard turned the matter into a brilliant victory and enlisted and received the support of the local police for the rest of his life. Less helpful, however, were Bernard's wife and daughter, for they turned on him and became crusading antivivisectionists.

An American medical student whose methods of investigating the digestive tract by x-rays are used the world over was Walter B. Cannon of Harvard. His autobiographical volume *The Way of an Investigator* is a primer that should be in the hands of students in all fields of science. One of Cannon's admirers, Sir Arthur Hurst, has given us an unforgettable account of Cannon overhearing an agitated conversation by two women on a tram in Boston, to the effect that scientists had developed a machine that could see right through a fully clothed person!

This pearl was not lost upon the young student, who had taught comparative anatomy for some time at Radcliffe College to support himself and was thus well qualified for animal experiments on

swallowing and on the little-known motions of the digestive tract. First with buttons, then with bismuth, and later with barium, Cannon probed these mysteries of the gut, in cats, geese, dogs, frogs, and eventually human beings. A by-product of the work on cats—one morose cat in particular—led Cannon into a new field, ripe for study: the effect of the emotions on body functions.

There is no better place in which to discuss student discoveries than in the realm of endocrinology. The insulin-secreting cells of the pancreas were found by Paul Langerhans, a medical student who came from a long line of physicians and pathologists in Jena. While he was a student in Berlin, he was recognized by Virchow as someone worth providing laboratory space for, and Cohnheim gave him every encouragement. In his graduation thesis he presented his work of the preceding 2 years on the cell types of the pancreas, in which he described for the first time, the islet cells now known to produce insulin. His paper was full of humility, and it called on anatomists to give more attention to the complex structure of the pancreas.

A like spirit, Ivar Sandstrom, in first-year medicine in Uppsala, was soon to discover the parathyroid glands, first in the dog and then in man. His incredulous reaction was not shared by his sympathetic and helpful teacher, who urged him to follow up his suspicion with gross and microscopic investigations designed to clinch the point.

Student contributors in the field of the nervous system have been legion. For our purposes here it is necessary to refer only to a few. The first, Francesco Gennari, was a medical aspirant in Parma, working under the benign eye of the pathologist Girardi, when he discovered the white line in the occipital cortex of the brain. The possibility that localization, in the brain, of special function might go hand in hand with special structure was raised by Gennari's work.

Johannes Purkinje, that great Czech figure and forerunner of the theory of evolution and of the cell theory, wrote a student thesis on color vision that assured his future. It came to the notice of Goethe the poet and, through him, to the brothers von Humboldt. As a result Purkinje was appointed to the chair of physiology in Breslau. When the professors there protested against this "foreigner" and petitioned Berlin for his removal, the Prussian government replied by building for Purkinje the first physiological research laboratory in Europe!

In the Berlin laboratory of Johannes Müller, the medical students Robert Remak and Hermann von Helmholtz showed that nerve fibers were derived from nerve cells in vertebrates and invertebrates. Helmholtz soon sought the field of physics and, while serving his army internship, as a state-subsidized student, in the Potsdam army barracks, he wrote his treatise, not inappropriately, on *The Conservation of Energy*.

The controversy that has surrounded the figure of Sigmund Freud has obscured his true greatness as a comparative neuroanatomist. What he wrote as a medical student is basic to our daily clinical work in neurology. His figures on the derivation of the T-shaped dorsal root ganglion cells of spinal cord are used universally. His painstaking work on phylogenetic levels in the development of the nervous system formed the basis for his later theory of the levels of consciousness in man.

We must contemplate for a moment the student work of Charles Sherrington, who has been truly called "the philosopher of the nervous system." His undergraduate researches are of great interest today, when entire hemispheres of human brain and large tracts of the spinal cord are being sectioned. His first paper dealt with the effects of hemisection of the spinal cord, and his second with the effects of removing one cerebral hemisphere in the dog. From such beginnings in the laboratories of Cambridge University a great and noble career developed.

The story of the circulation of the blood and lymph is charged with the names of undergraduate works. As Leake's delightful translation of *Du Motu Cordis* has noted, William Harvey was a student investigator while he was a pupil of Fabricius in Padua around 1600. After watching the alternate reddening and blanching of the node that was to become the heart of the embryonic chick, his mind turned to the pump, not the blood, as the secret of the circulation.

The forerunner of the mercury manometer, which we surreptitiously watch whenever our blood pressure is being taken today, was developed by the student J. L. M. Poiseuille and described in his graduation thesis in Paris in 1828. No sooner had he graduated than he developed his well-known "law" concerning the speed of currents in capillary tubes and its relation to the square of the tube's diameter.

The discovery of the true circulation of the lymph in the body is entirely the work of medical students. Pecquet in France, Joyliffe in England, and the colorful Rudbeck in Sweden were all undergraduates when they independently described the emptying of the lymphatic system into the great veins. Jan Swammerdam, the Dutch medical student, discovered the valves in the lymphatic vessels soon after his discovery of the red blood corpuscles in 1658.

The field of pathology and bacteriology boasts

such student investigators as Paul Ehrlich, Jenner, W. G. MacCallum, and above all Rene Laennec.

Ehrlich was a chemical investigator from an early age. As a medical undergraduate he grasped the significance of the selective staining of tissues by aniline dyes and contributed his first papers on stains for the blood and stains for lead deposited in tissues. With his marvelous ability to picture molecular stereostructure, he predicted many new therapeutic compounds and as a student developed the basic concepts of his now famous side-chain theory.

Edward Jenner had scarcely begun his apprenticeship training in medicine in Gloucestershire when he learned from a dairy maid that those afflicted with cowpox were protected from smallpox. He pondered this idea while he was a medical student in London, discussed it with John Hunter, and finally, upon graduation and further observation, put it to the critical test in planned vaccinations.

While he was a medical student at Johns Hopkins University, William G. MacCallum worked out the life-cycle of malaria in birds in a masterly investigation. Rene Laennec, the father of the stethoscope, produced a remarkable paper on peritonitis while he was a medical student in Paris, at the age of 19.

Finally we come to John Shaw Billings, who in the opinion of some observers has made the greatest American contribution to medicine—greater even than surgical anesthesia. Billings was a student at a liberal arts college when he first showed signs of resolute action in the face of his chief enemy—ignorance. On finding that the college library was open only on Saturdays, he made a key and quietly opened it on the remaining 6 days of the week and, in fact, enjoyed all the privileges of a private library of 6000 volumes. He sampled most of these volumes, progressing around the shelves geographically. By the time he entered medical school in Cincinnati Billings had a liberal education behind him but only 50 cents per week for food ahead of him. The medical course was 2 years in length, the second year being almost a repetition of the first!

Billings' great discovery stemmed from his graduation thesis requirement. His subject was the value of neurosurgical intervention in epilepsy. Billings soon found that the few medical volumes available from all sources in Cincinnati were of no assistance on this subject. He next discovered that no one really knew where such information could be found for certain. His professors thought there must be something written on it elsewhere, in Philadelphia perhaps, or in Europe. What began as an inquiry into epilepsy soon became an explosive and fearsome discovery in the hands of Billings. He decided, as a student, that before he died he would set this matter right, and he did.

At the close of the Civil War Billings was given the unspent remainder of the canteen funds for his projected surgeon general's library. He set out to buy as many books as the U.S. budget would allow, at the same time cataloging in an orderly fashion all the printed books in the world bearing on medicine. The catalog of the Surgeon General's Library represents one of the greatest feats in literary history. It is carried on in slightly different form today, but it still represents one of America's greatest contributions to medical science.

Billings designed the Johns Hopkins Hospital in Baltimore and the Peter Bent Brigham Hospital in Boston and was one of the moving spirits in medical educational reform in the United States. His swansong was the designing and construction of the New York Public Library. No student ever contributed more to medical science than did John Shaw Billings.

Thus ends this necessarily limited review of the scientific contributions by medical students. The one thing, above all others, that strikes us repeatedly in this analysis is the motivating force in these men, so well epitomized by Osler in one of his student notebooks:

> Experience is to be measured not by the time served but by the use which a man made of his opportunities.

*Where neither confirmation nor refutation is possible, science is not concerned. Science acts and only acts in the domain of uncompleted experience.*—Ernst Mach, *Science of Mechanics.*

# An Orientation toward Modern Physical Theory

MARSHALL J. WALKER

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THE purpose of theoretical physical science is to postulate a conceptual model of nature from which the observed behavior may be predicted quantitatively. The method is (i) postulate a model based on existing experimental measurements; (ii) check the predictions of this model against further measurements; and (iii) adjust or replace the model as required by the new measurements. Step iii leads back to step ii, and a cyclic repetition of ii and iii takes place until a completely new model is introduced; then step i has recurred, and the process continues without end. No claim is made about the "reality" of the model; the sole criterion is successful prediction from the simplest or most convenient or most satisfying model.

Physical science is cumulative: that is, the current model includes all the successful parts of previous models. Mathematically, this usually means that the previous model is a special case of the new model and that all the successful parts of old models can be derived from the current model. On the other hand, the new model cannot be derived or deduced from the old one—it must be postulated and then tested. New models are often quite radically different from the old ones and often require the abandonment of ideas that have long been considered obvious and axiomatic. ("The obvious is difficult to prove and often untrue."—Bertrand Russell.) New theories thus tend to sound like nonsense, even to other physicists, and nearly all the new theories have been introduced by comparatively young researchers. Seemingly, most workers beyond their thirties cannot "unlearn" their axioms convincingly enough to introduce radically new ideas. Furthermore, the older scientists seldom develop much aptitude in the use of the new theories, even when they try to cooperate completely with the newer point of view.

The afore-described process can be illustrated by certain portions of the history of physics. Direct naked-eye observations of the apparent motions of the sun, moon, planets, and stars suggested to the later Greeks that these heavenly bodies revolved around the earth as a center. More careful observations revealed that the apparent movements were highly irregular, and Aristotle was forced to postulate 55 simultaneous motions in an attempt to modify this simple model to account for the known behavior.

The observation of the retrograde motion of some planets led to the Ptolemaic theory of epicycles. In this ingenious theory, a planet did not move in a large circular orbit around the earth but actually moved in a small circular orbit (an epicycle) and the *center* of this epicycle moved around the earth in a large circular orbit called the *deferent*. By adjusting the radii of the epicycle and the deferent, one could account for the retrograde motions but at the expense of a rather complicated model.

Copernicus (1473–1543) showed that retrograde motion could be accounted for by assuming that the sun was near the center of a system of circular orbits in which the earth and planets moved with fair regularity. Since anyone could see that the planets moved around the earth, this theory was clearly nonsense. In time people got used to this nonsense, and it became sensible.

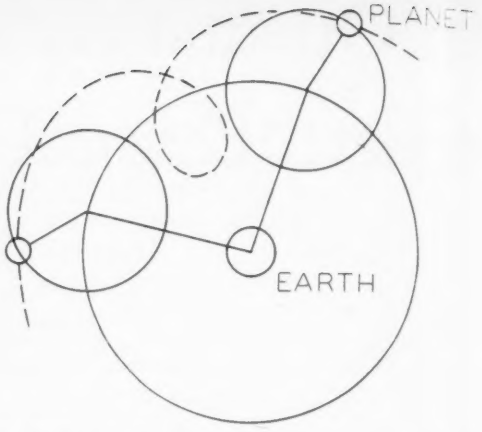
There were still many small discrepancies between observations and the predictions of the model, but more accurate measurements were needed to convince people that the Copernican model could not be patched up to fit the observations. These accurate measurements were provided by Tycho Brahe (1546–1601), the Danish astronomer, who made a lifelong study of the planets and gathered great quantities of measurements. His assistant, Johannes Kepler (1571–1630), studied these measurements and formulated the model embodied in *Kepler's laws*. That is, if the following three laws are assumed, then the positions of the planets can be calculated for any specified instant

of time. (i) Each planet moves in an elliptical orbit around the sun, and one focus of the ellipse is located at the sun. (ii) The area swept out by the radius in a fixed length of time is constant for any part of the elliptical motion (that is, the planet moves fastest when closest to the sun). (iii) The square of the time needed for one revolution around the sun by each planet is proportional to the cube of the semimajor axis of the orbit of that planet. Accurate predictions could be made from this model, and these predictions checked very well with observations. The attention of physicists shifted from trying to invent a new model to an attempt to understand better the actual model in use.

The next major improvement in theory came with Isaac Newton (1642–1727). He made the following postulates. The first three have become known as *Newton's laws of motion* and the fourth as *Newton's law of gravitation.* (i) A body if at rest remains at rest, or if in motion remains in motion in a straight line at constant velocity, unless acted upon by an external resultant force. (ii) The acceleration of a body is directly proportional to the applied force and inversely proportional to its mass. (iii) If a body *A* exerts a force *F* on a body *B,* then body *B* exerts on body *A* a force that is equal in magnitude but opposite in direction to force *F.* (iv) Any two masses are attracted toward each other by a force directly proportional to the product of the masses and inversely proportional to the square of the distance between their centers. From these postulates Kepler's laws can be derived; hence, they predict successfully anything that Kepler's laws predicted. Further, they apply to any motion and, thus, are more general than Kepler's laws, which applied only to elliptical planetary motion. For example, the orbits of some comets are not elliptical, but Newton's laws predict the motion accurately.

Note that the word *mass* occurs in Newton's postulates ii and iv with quite different contexts. Postulate ii refers to an *inertial mass,* whereas postulate iv refers to *gravitational mass.* There is no *a priori* reason why these should be equal, but Newton assumed that they were equal and was successful in making quite accurate predictions. In 1891 Eötvös checked the equality of these two quantities by very accurate measurements, and later Einstein used the equality in developing his theory of gravitation.

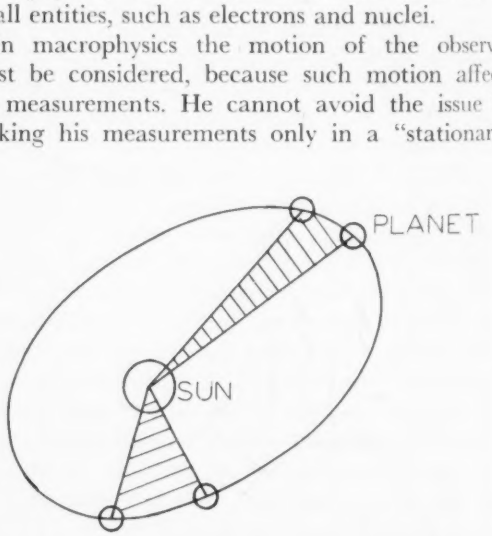
Newton's theory permitted physicists to say that they "understood" Kepler's model, for a physicist says that he "understands" a phenomenon if he regards it as a special case of a more general law. Clearly the most general law at a given time in history cannot be "understood" in this sense. Philosophers found Newton's ideas to be nonsense but, as usual, got used to them in time. Kant (1724–1804) assumed Newtonian mechanics as axiomatic.




In the Ptolemaic model of the solar system, each planet moves in a small circular orbit, an epicycle, and the center of the epicycle moves round the earth in a larger circular orbit, the deferent.

Until the latter part of the 19th century, scientists had neglected to consider the effect of the observer on physical measurements. These effects are usually small, and the accurate measurements of the 19th century were needed to show their existence. Consideration of the observer has led to the present division of physics into two parts: *macrophysics,* which deals with the behavior of large objects, such as planets and baseballs; and *microphysics,* which deals with the behavior of small entities, such as electrons and nuclei.

In macrophysics the motion of the observer must be considered, because such motion affects his measurements. He cannot avoid the issue by making his measurements only in a "stationary"




Kepler's second law of planetary motion: The area swept out by the radial line from the sun to the planet covers equal areas for equal periods of time of the planet's motion along its orbit. (Ellipticity exaggerated)

laboratory, because, viewed from the sun, that laboratory itself is spinning through space at 18 mi/sec. This introduces a rather large effect. On the other hand, the act of observation does not measurably disturb objects having large mass. Mars is observed by light from the sun that is reflected from the surface of Mars. This reflection does not disturb the orbit of Mars appreciably.

In microphysics not only the motion of the observer must be considered but also the effect of the act of observation upon the thing observed. When an electron is observed by "reflecting" light from it, the electron is disturbed in an unpredictable way.

The aspects of general mechanics most directly useful in macrophysics are studied in the restricted and general theories of relativity. The aspects of general mechanics most directly useful in microphysics are studied in *quantum mechanics*. These will be considered in order, but first the concept of a *coordinate system* must be introduced.

A coordinate system is a method for precise specification of positions. First a starting position, the *origin*, must be adopted. If the origin is a mark on the pavement, then a man's hat can be located by saying that the hat is 8 ft north, 3 ft east, and 6 ft above the origin. These three numbers are the spatial coordinates of the hat. A change in the origin or some other agreement about the method of location would yield three other numbers, but in three-dimensional space precisely three numbers will be needed. The origin might be chosen as a mark on the floor of a truck; then the driver's hat has coordinates independent of time, but a passing lamp post has coordinates that depend on time.

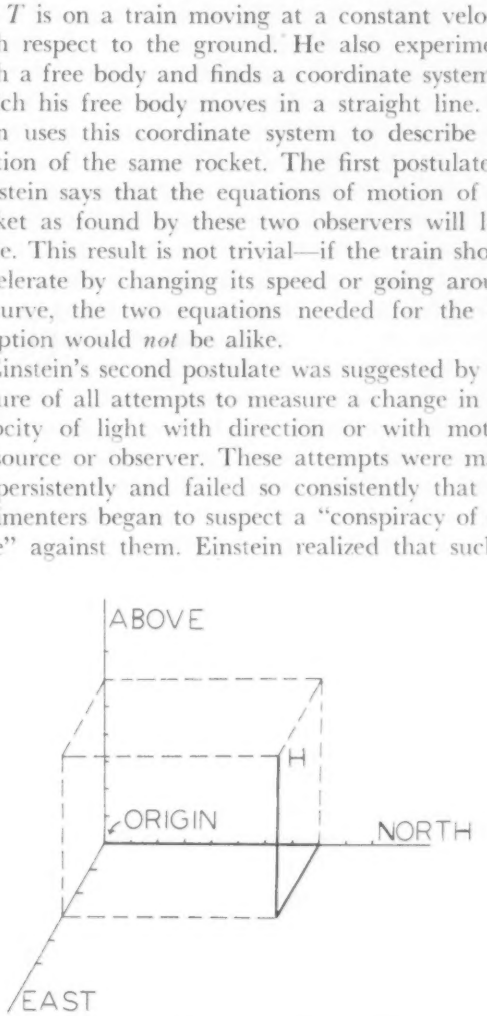
## Restricted Relativity

The theory of restricted relativity was advanced by Einstein in 1905; it rests on two basic postulates. (Their historical origin is discussed later.) (i) The laws of physics are the same when derived from measurements of any two observers whose respective inertial systems are moving at constant relative velocity with respect to each other. (ii) The velocity of light is a constant independent of the direction of propagation or of the motion of source or observer. In what sense are "the laws of physics the same"? The mathematical relationship between the position measurements made by two observers moving with constant relative velocity was first worked out by H. A. Lorentz (1853–1928) and has become known as the *Lorentz transformation*. Technically speaking, the first postulate requires that any equation embodying a proposed physical law must be "invariant under the Lorentz transformation." That is, the two equations arrived at by these two observers will look alike and correspond exactly, although the values of the quantities entering the equations at a particular instant of time will be different.

Each of these two observers, however, must make his measurements with respect to an *inertial system*. A coordinate system is "inertial" when Newton's second postulate (which defines inertial mass) accurately describes the behavior of a free body moving under no forces. In short, an inertial system is one in which a free body moves, if at all, in a straight line at constant velocity.

Now for an example. Suppose there is an observer $G$ stationary on the ground. He experiments with a free body and discovers or invents a coordinate system in which the free body moves in a straight line. He then uses this coordinate system to describe the motion of a rocket. Another observer $T$ is on a train moving at a constant velocity with respect to the ground. He also experiments with a free body and finds a coordinate system in which his free body moves in a straight line. He then uses this coordinate system to describe the motion of the same rocket. The first postulate of Einstein says that the equations of motion of the rocket as found by these two observers will look alike. This result is not trivial—if the train should accelerate by changing its speed or going around a curve, the two equations needed for the description would *not* be alike.

Einstein's second postulate was suggested by the failure of all attempts to measure a change in the velocity of light with direction or with motion of source or observer. These attempts were made so persistently and failed so consistently that experimenters began to suspect a "conspiracy of nature" against them. Einstein realized that such a




Coordinate system: The position $H$ can be located uniquely by saying that $H$ is 8 ft north, 3 ft east, and 6 ft above the chosen starting point, or origin.

conspiracy was in itself a law of nature and wrote it as his second postulate.

This second postulate is related to the fact that the velocity of light (the only practical synchronization signal) can be measured only for a round trip. A one-way trip cannot be timed, because it would require the synchronization of timers at different places, and this in turn requires a knowledge of the one-way velocity of light. The experimentalists are caught in a vicious circle. They cannot synchronize the timers and then move them apart, because (as is shown later) such acceleration ruins the synchronization of the timers. The "conspiracy of nature" just mentioned has come back in a different guise. If an experimenter asks a silly question of nature he gets a silly answer. Einstein recognized the silliness of the question in this way: It had been assumed that an absolute time existed such that any timers anywhere could be synchronized with it. Nature was pointing out most emphatically that such absolute time does not exist. It will be seen later that, in general, it is as nonsensical to expect to find the same "time" at two different places as it is to expect to find the same "point" at two different places.

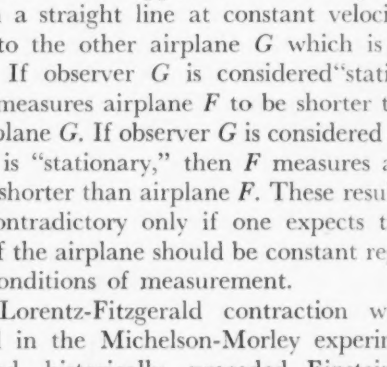
Einstein's second postulate permits the definition of a kind of "simultaneity" at different places by accepting the arrival of a light signal as a definition of zero time. To "synchronize" watches on, respectively, Mars, the earth, and the moon, a flash lamp is fired on the earth at zero on the earth timer. The timers on Mars and the moon are started at zero when the flash signal arrives. Any attempt to allow for the time of flight gets one involved in a maze of circular reasoning.

From Einstein's two postulates one can derive mathematically a series of inferences which still seem almost nonsense, although they have all been observed experimentally. (i) The length of a moving body (say an airplane) is shorter when measured by a stationary observer than when measured by an observer on the airplane ("Lorentz-Fitzgerald contraction"). (ii) The frequency of a vibratory motion on a moving body is less when measured by a stationary observer than when measured by an observer on the moving body ("time dilatation"). (iii) The velocity of a motion on a moving body is less when measured by a stationary observer than when measured by an observer on the moving body ("no object having mass can travel faster than the velocity of light"). (iv) The mass of a body in motion is greater when measured by a stationary observer than when measured by an observer moving with the body ("mass increases with velocity").

In brief, statements like the foregoing hold for all physical quantities: kinetic energy, momentum, and so forth. The difference between the two observations would be negligibly small for airplane velocities, but the difference becomes larger as the relative velocity increases and approaches infinity as the relative velocity approaches the speed of light.

In these deductions, as elsewhere, the word *stationary* is merely a label for the coordinate system that one chooses to consider as "stationary." In the foregoing deduction i, one can consider that the airplane is moving with respect to a "stationary" ground or that the ground is moving with respect to a "stationary" airplane. Suppose that there are two airplanes each containing an observer. Each observer measures the length of each airplane when they are stationary with respect to each other. These four measurements are found to be identical. Now suppose that one airplane $F$ is flying in a straight line at constant velocity with respect to the other airplane $G$ which is on the ground. If observer $G$ is considered "stationary," then $G$ measures airplane $F$ to be shorter than his own airplane $G$. If observer $G$ is considered moving while $F$ is "stationary," then $F$ measures airplane $G$ to be shorter than airplane $F$. These results seem to be contradictory only if one expects that the length of the airplane should be constant regardless of the conditions of measurement.

The Lorentz-Fitzgerald contraction was first observed in the Michelson-Morley experiment in 1887 and, historically, preceded Einstein's first postulate. We have here the usual procedure that the theorist attempts to postulate a simple, general law from which an already observed effect can be




On a spherical surface, the angles of a small triangle add up to 180 deg, but the angles of larger triangles add up to more than 180 deg.

inferred. When, as here, the postulates lead to several unexpected inferences that are later confirmed by experiment, the theory is considered to be successful.

Thus far the theory has been "restricted" in that it pertains only to what is measured by observers moving with a constant relative velocity. If the observers move with variable relative velocity, the theory must be generalized, and this leads to the *general theory of relativity*. The case of variable velocity is important because any problem involving rotation involves variable velocity. An automobile traveling in a circle at the constant speed of 30 mi/hr has a variable velocity, because the direction of its speed is constantly changing. A velocity can change in direction, in magnitude, or in both together.

### General Relativity

General relativity originated as a generalization of the restricted theory, which itself was developed during study of the *ether* problem. Many theorists had tried to invent a model that would throw some light on the mysterious action-at-a-distance of Newton's law of gravitational attraction. Most of these models involved the postulation of a peculiar substance called "the ether," which permeated all space and was invoked to explain action-at-a-distance. The explanations were not very convincing, and the physical properties required by the ether were so self-contradictory that the ether theories were constantly under suspicion.

Light traveled through the vacuum of space and was regarded as a wave propagating through the ether. The ether was presumably at rest, since it could hardly be imagined to travel along with all the diversely moving planets at once. If the earth, moving in its orbit, passed through this stationary ether, and light was a wave in that ether, then the velocity of light ought to be different when measured along the orbital path or when crosswise to it. The Michelson-Morley experiment of 1887 found no such difference in velocity.

This situation and the equality between inertial mass and gravitational mass suggested to Einstein that the properties needed to predict gravitation should be assigned to space itself. The distinction between "space" and "ether" is largely semantic, but semantic overtones are as useful in science as in poetry, and the semantic overtones of the word *space* suggested several interesting ideas. In particular, it suggested that physical space might not obey Euclidean geometry. Mathematicians of the 19th century had invented all sorts of abstract mathematical "spaces" and studied their properties, that is, their geometries. Riemann (1826-66) specifically had studied a general kind of geometry which included Euclidean geometry as a special case, and Einstein chose to investigate the assumption that physical space might follow Riemannian geometry. In particular, he postulated a Riemannian space of four dimensions—the three dimensions of familiar space plus a fourth related to time. This procedure joined space and time into a four-dimensional unity called the *space-time continuum* and thereby led one to expect that different points would, in general, have different "times" also.

One can get an idea of the properties of Riemannian space by considering conditions on a spherical surface, because the surface of a sphere is a two-dimensional Riemannian space. Imagine a being who can comprehend only two dimensions. This Flatlander has lived all his life on the surface of a big sphere, but he has lived in such a small area that the surface differed negligibly from a Euclidean plane. He is quite sure that if he should travel in a "straight line" he could go on forever unless he encountered the boundary of his space, and he finds himself quite unable to imagine such a boundary. When he measures a small right triangle he finds that the Pythagorean theorem is true: The square of the hypotenuse equals the sum of the squares of the other two sides within the accuracy of his measurements. When he measures the angles of his small right triangle, he finds that their sum is 180 deg.

Now let us suppose that this Flatlander becomes able to travel and make measurements over large areas of space. If he attempts to travel in a "straight line forever" he finds that he can circumnavigate his space in any direction without encountering a boundary. Apparently his space is finite in area but has no boundaries; this baffles his imagination. Furthermore, the angles of his triangles add up to anything between 180 deg and 540 deg, depending on the size of the triangle. The hypotenuse of a large right triangle as measured from actual triangles in his space deviates seriously from the Pythagorean theorem.

About this time a Flatland mathematician was pondering the fact that length measurements seemed to come out "wrong" in the sense that the Pythagorean theorem did not hold for large triangles. It occurred to him that a Flatlander who actually was measuring a curved arc, when he thought he was measuring a straight line, would get the "wrong" answer if he used a theorem whose proof demanded straight lines. The lines along the sides of his big triangles were obviously straight

to any Flatlander, so the mathematician postulated that his space itself was curved in some mysterious way that he could not see but could infer from his measurements. This *curvature of space* was nonsense, as any Flatlander could see, but the mathematician used the concept and succeeded in "predicting" the results already observed.

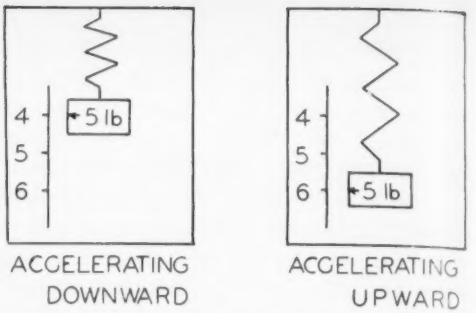
The extension of these ideas to our own space is clear. The Flatlander lived in a two-dimensional space of finite area, although he could neither locate nor imagine a boundary. Our own space would accordingly have finite volume, and we would be similarly puzzled by the lack of a boundary. The Flatlander inexplicably found he could circumnavigate his space by traveling in what seemed to him a "straight line"; our own space may have a similar property.

Here we find a need for a larger vocabulary. What appears to be a straight line in two-dimensional space may be curved from the viewpoint of three-dimensional space. Presumably the straight line of three-dimensional space may be curved from the viewpoint of four-dimensional space, and so on. We need a word for the "straightest" line—that is, the shortest distance between two points in a given space—and this word is *geodesic*. Thus the geodesic on a spherical surface is a great circle. To see how these ideas can be applied to the gravitational problem, we must first consider how Newton dealt with the situation.

In Newton's theory planetary motion is explained as follows. A moving planet moves "naturally" in a straight line at constant speed unless it is influenced by an applied force. Thus, the earth deviates from a straight-line motion because of an attractive force from the sun. This attractive force is enough to pull the earth into a curved path around the sun but not enough to pull the earth into collision.

In Einstein's theory, a moving planet moves "naturally" along a geodesic at constant velocity. The earth moves around the sun because the gravitational effect of the sun's mass has deformed space so that a geodesic has the shape of the earth's elliptical orbit.

An ingenious (but somewhat misleading) analogy of space deformation has been invented. Imagine a tight sheet of rubber stretched horizontally like a drumhead. If several balls of different masses are put down at random on the sheet, each ball will depress the rubber sheet near it and lie at the bottom of a local valley. Neighboring balls tend to roll down each other's valley and thus appear to attract each other. The misleading aspect of this analogy is the necessity for a downward gravitational pull common to all the balls.




The weight of a box as measured on a spring balance in an elevator changes if the elevator accelerates.

On the other hand, the space (the rubber sheet) is deformed in proportion to the mass of each ball, as it is in the actual theory.

Now we shall see how these ideas were introduced by considering the actual postulates of Einstein's general theory. These postulates include those of the restricted theory and also the following. (i) At a particular point of space it is impossible for an observer to distinguish whether a force is due to gravitational attraction or to his own accelerated motion ("principle of equivalence"). (ii) The path of a material particle acted upon only by gravitation and its own inertia is a geodesic. This geodesic depends upon the curvature of space that is determined by the gravitational field.

As an illustration of postulate i, consider a man standing in an elevator stationary with respect to the ground and holding a box in his hand. The man feels a downward pull on the box owing to the gravitational pull of the earth below him. This pull he calls the *weight* of the box. When the elevator accelerates upward, the box feels heavier. If the man does not know that he is accelerating, he could conclude that the mass of the earth had somehow increased miraculously and thus was exerting a greater attraction on the box.

Postulate ii (Einstein's law of gravitation), which has been stated in words, is actually a deceptively simple-looking equation when it is written in the customary way using tensor symbols. A tensor may be regarded as a generalization of a vector, and it is particularly suitable for the mathematical aspects of relativity, because a tensor does not depend on the specific coordinates system in use. The components of a tensor change as the coordinate system is changed, but the magnitude and direction of the tensor remain constant. When a solid object is forcibly deformed the stress observed in different directions is described by a tensor. It is clear that the stress is a physical condition in a given situation and cannot depend on the choice of the coordinate system. Postulate ii con-

tains Newton's law of gravitation as a special case.

From these two postulates one can derive mathematically the following inferences. (i) A light ray that passes close to a massive object (such as the sun) will be bent toward it by an amount depending on the mass of the object. The light travels along a geodesic, and the massive object distorts space in its vicinity. This effect has been observed during a total eclipse of the sun as a shift in the apparent position of stars whose light rays pass close to the sun. (ii) Atomic processes in an intense gravitational field are slower than elsewhere by an amount depending on the strength of the field. This effect is small and hard to measure accurately, but it appears that lines in the spectrum of the sun are shifted slightly compared with the corresponding lines emitted by elements on the earth. (iii) The orbit of the planet Mercury should deviate by 0.012 deg per century from the position predicted by Newton's theory. This 0.012-deg deviation had been observed before Einstein's theory was formulated, and the theory thus explained an already known fact. This particular fact, however, was of no use to Einstein in constructing the theory, because the mathematical computation of this number is much too complicated to be traced backward and its origin postulated *ad hoc*.

The general theory of relativity thus explains the gravitational field accurately. It would be very satisfying if the electric and magnetic fields could also be derived from the same or similar considerations. To date, it has not been possible to do this satisfactorily, and the *unified field theory* remains the subject of current research.

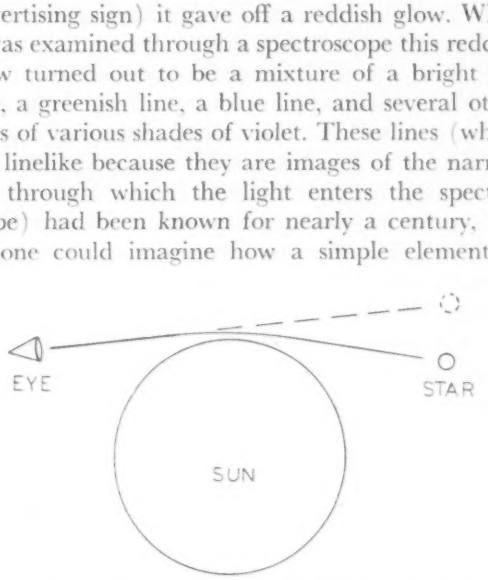
## Microphysics

We have seen the far-reaching effects on macrophysics introduced by consideration of the motion of the observer. Consideration of the effect on the system of the act of observation leads to equally important results in microphysics.

The first hint of things to come was found by Max Planck (1858–1947) in 1900. Experimentalists had studied the color and amount of light given off from a cavity in a glowing solid and found that the color was the same for all materials held at any fixed temperature. When the temperature was changed, the color of glowing solids of all materials changed in the same way. As the solid was heated, its color changed from dull red through pale orange and yellow to a bluish white. Since this change was the same for all solids, it seemed that it could be explained without knowing much about the actual structure of any particular solid. Theorists were attracted to this situation like crows to a cornfield. Wien (1864–1928) derived an equation that worked well for the bluish colors but failed for the reddish ones. Rayleigh (1842–1919) and Jeans (1877–1946) each derived a second equation that worked well for the reddish end and failed elsewhere. Planck derived a third equation that fitted the whole range but only by making a postulate that seemed even to him to be practically nonsense. This postulate was: Radiant energy is not continuous but comes in particles. The energy content of a particle is equal to the frequency of the light multiplied by a constant number represented by the letter $h$. The *frequency* of the light is a number that specifies the color of the light; the frequency of red light is about half that of blue light. Clearly these particles (called *quanta* by Planck and later called *photons*) are not all alike but depend on the color of the light. A quantum of blue light has about twice as much energy as a quantum of red light.

This notion of quantized radiation received further support in 1905 when Einstein needed the same postulate in order to "predict" the behavior of electrons ejected from a metal surface by incident radiation.

Acceptance of this *quantum theory* was finally achieved through the success of a model of the hydrogen atom proposed by Bohr (1885– ) in 1913. Hydrogen was the lightest and, presumably, the simplest of all the four-score different atoms then known. When hydrogen gas was sufficiently heated or excited electrically (as in a tubular advertising sign) it gave off a reddish glow. When it was examined through a spectroscope this reddish glow turned out to be a mixture of a bright red line, a greenish line, a blue line, and several other lines of various shades of violet. These lines (which are linelike because they are images of the narrow slit through which the light enters the spectroscope) had been known for nearly a century, but no one could imagine how a simple elementary




The measured position of a star changes if the light ray from the star traverses a region of strong gravitational pull.

atom like hydrogen could produce so much variety.

Bohr's model was based on the following postulates. (i) The hydrogen atom consists of a massive, positively charged nucleus with a single negatively charged electron moving like a planet in a circular orbit around the nucleus according to Newton's laws of motion. (ii) The electron may be in any one of a number of possible definite orbits; the possible orbits are those for which the angular momentum of the electron is an integral multiple of the Planck constant $h$ divided by $2\pi$. (iii) The electron does not radiate any light when it revolves in any one orbit, but it does radiate 1 photon when the electron changes from a larger to a smaller orbit. The "color" (that is, frequency) of the photon depends on the change—red for a change from orbit 3 to orbit 2, green for a change from orbit 4 to orbit 2, and so on. The Bohr model provides no detailed picture of what happens when the electron changes to a smaller orbit; the model gives only the end-result, that a photon is emitted with a specified energy equal to the change in energy of the atom.

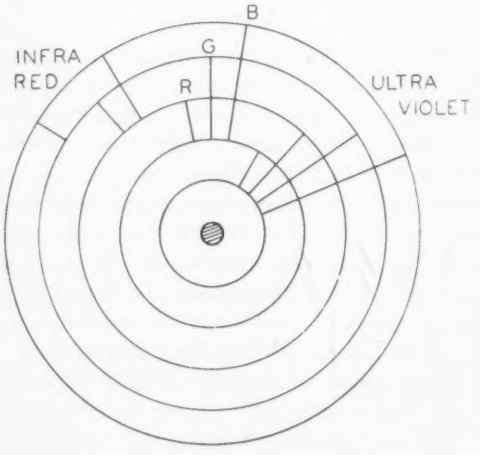
The massive nucleus of Bohr's first postulate had been suggested in 1911 by Rutherford (1871–1937) on the basis of experimental results obtained by Geiger and Marsden in 1909. They had bombarded the atoms in a piece of platinum foil with the high-speed alpha-particles that are emitted by radioactive materials like radium. They found that some of these particles were deflected violently by the foil, thus indicating that the platinum atom must have a very hard and solid core. If you are firing machine gun bullets at a pile of raisin buns and some of the bullets bounce nearly backward, you will infer that the buns contain something harder than raisins.

The Bohr model "predicted" quantitatively all the then known colors emitted by the excited hydrogen atom. In addition it predicted others, some in the invisible region beyond the violet (ultraviolet), and others in the invisible region beyond the red (infrared). When these spectrum lines were later found by instrumental means, the Bohr model was considered well established. Note that a particular hydrogen atom emits only 1 photon per jump, but that a tube of glowing hydrogen contains billions of atoms, each contributing a photon corresponding to its own particular change of orbits. The electron is usually in the smallest orbit, but can be knocked into an outer orbit by heating or exciting the gas by electric means. When the electron returns to an inner orbit the appropriate photon is emitted.

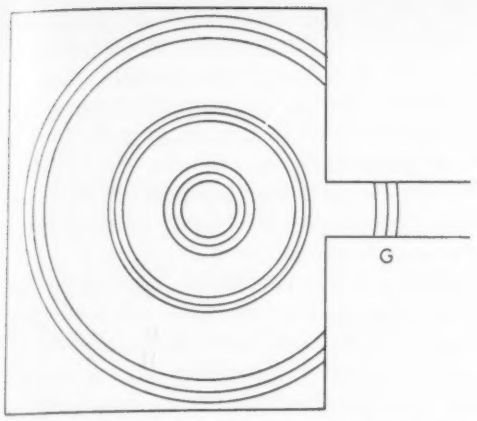
These ideas were extended to the other atoms. Helium was pictured as a doubly charged nucleus with 2 electrons; lithium as a triply charged nucleus with 3 electrons, and so on through the list of chemical elements. The Bohr model made accurate predictions for hydrogen and fairly accurate predictions for helium; but for lithium and heavier elements, the model became less and less accurate. Attempts were made to modify the Bohr model (for example, by the use of elliptical orbits), but it soon became clear that a more radical change was needed.

Planck had shown that light waves sometimes behave as if they were particles. One can visualize this by imagining the photon as a discrete group of waves. When a stone is dropped into a still pond a circular group of waves spreads out from the central disturbance. If a narrow ditch opens into the pond, a narrow section of the circular waves will travel up the ditch acting much like a particle moving along the water surface. Here we have a wave group acting like a particle.

In 1924 de Broglie suggested that a particle might also behave like a wave under some circumstances. In particular he postulated a method to compute the wavelength of an electron: The wavelength of an electron moving at a specific velocity can be computed by dividing the Planck constant $h$ by the momentum of the electron. When light from a distant street lamp is viewed through an ordinary window screen, one sees a cross-shaped pattern of light. This *diffraction pattern* is easily explained using the wave aspect of light. In 1927 Davisson and Germer "looked at" a beam of electrons reflected from a "window screen" made of




Bohr model of the hydrogen atom. The circles represent some of the possible orbits of the single planetary electron. The radial lines represent possible changes of the state of the electron. *R*, *G*, *B* show the transitions corresponding to the red, green, and blue spectral colors.




Stones dropped into a still pond produce circular waves spreading out from the center. The wave group $G$ is a portion of the original circle. The group travels up the narrow channel and maintains its identity rather like a particle. (Reflections from the sides have been omitted.)

the regular arrangement of atoms in a metal crystal. They observed a diffraction pattern, and the de Broglie wavelength of the electron explained the effect quantitatively. Here we have an electron (previously considered only a particle) acting like a wave. C. G. Darwin suggested that such things ought to be called *wavicles*.

When the wave aspect of the electron is applied to the electron in the Bohr model of hydrogen, a very interesting picture appears. The various possible orbits are just those for which an integral number of electron wavelengths will exactly fit the circumference of the orbit. The smallest orbit is 1 wavelength in circumference, the next orbit is 2 wavelengths in circumference, and so on. Instead of picturing the electron as a particle traveling around and around the orbit, one pictures the electron as a wave spread simultaneously around the whole orbit and closed on itself. The electron, as it were, occupies the entire orbit simultaneously.

The wavelength of the electron requires us to think what we mean by "locating" the electron at a point. The electron may act like a particle, but it is also spread out like a wave. One can locate an octopus by giving the coordinates of its beak, but it would be unwise to forget that neighboring coordinates for 2 or 3 yd out in all directions have considerable probability of being occupied by octopus at a given instant. If now, our octopus is in a rather large dark room, so that even its beak cannot be seen and located exactly, then we have the situation of modern physics in trying to locate an electron or other small particle. One is forced to give up the notion of precise location and must accept statements like this: "The octopus is certainly somewhere in the room, but we don't know where, so we will say that there is probability that one will encounter him anywhere." In brief, the probability distribution of octopus fills the whole room. If there is a supply of octopus food in the center of the room, then the probability distribution may be more concentrated there.

Here we must consider just how an electron is located. The octopus can be located by using a flashlight—the light is reflected from its surface and locates it. The light when it reflects from the octopus' surface gives it a slight push, but the octopus is so massive that it is not moved appreciably. The attempt can be made to locate an electron by "reflecting" light from it also, but in this case (since the electron has so little mass) the reflecting light kicks the electron violently to some other position. Furthermore, all attempts to compute just where it went have failed. The reflected light tells us where the electron was a moment ago, but now it is no loger there, and where it is or what it is doing cannot be computed exactly.

Many experiments have been designed to locate small objects (such as electrons) precisely, and all such attempts have failed. This conspiracy of nature was cast into the form of a natural law by Heisenberg in 1927 as the *principle of indeterminacy*: (i) The range-of-uncertainty-of-position multiplied by the range-of-uncertainty-of-momentum cannot be smaller than the Planck constant $h$ divided by $2\pi$. Loosely speaking, if you know precisely where a small object is, then you cannot know what it is doing; conversely, if you know precisely what it is doing you cannot know where it is. In the Bohr model you know precisely the angular momentum of the electron in a given orbit, but you cannot know where it is momentarily in that given orbit.

This principle applies also to large objects, but then the uncertainty is so small that we are not concerned. The aim of classical mechanics (that is, mechanics before quantum theory) was to obtain an *equation of motion* that would specify exactly the position of a moving object for any given instant of time. This classical mechanics will not work for small objects like electrons; a new type of *quantum mechanics* has been developed since 1925 by Heisenberg, Schroedinger, and others to deal with small particles. In quantum mechanics one does not specify the position of an object as a function of time; one specifies instead a probability distribution as a function of time. A particle is located by saying, "At 3 sec past noon this particle has a 35-percent probability of being in this little volume, a 31-percent probability of being in this adjacent little volume . . ." and so on throughout

all of an extended region. This procedure sounds hopelessly vague, but it works beautifully.

Philosophers are divided on the interpretation of this situation. One group says that, if exact position is unmeasurable, one must conclude that the concept of exact position is not applicable to small objects. The other group says that mere unmeasurability does not disqualify a concept for fruitful use. Science, insofar as it is concerned only with predictability, need not take a stand on this question, but the pattern of future models and theory clearly depends on the theorist's attitude toward such matters.

Schroedinger in 1925 developed a theory of the behavior of electrons in atoms that has been very successful. As usual in such developments, it includes Bohr's model as a special case. The atom is described with a partial differential equation—the same type of equation for all atoms but differing in its parts to correspond to each particular atom. The solutions of this equation describe the structure and properties of the electronic part of the atom accurately. For example, the solution for the unexcited hydrogen atom is a rather complicated function of spatial coordinates. When it is visualized, one gets a picture of a positively charged nucleus surrounded by a spherical probability distribution for the electron. That is, one is likely to encounter the electron anywhere within this spherical region. Whether the electron is actually spread out over this spherical volume or is fairly localized but moving about rapidly within the volume is a moot question. The general consensus favors the latter view.

When, in the Bohr picture, the electron goes from the smallest orbit to the next larger orbit, the spherical probability distribution gets larger in the Schroedinger picture. Furthermore, the Schroedinger picture gives more details about the intermediate situations. The Schroedinger equation is definite about the emission of the photon for the reverse change, but the details of geometric visualization remain to be developed.

Also in 1925 Heisenberg developed a successful theory of the atom using a completely different method. Almost immediately it was shown that the Heisenberg and Schroedinger procedures were equivalent, and now theorists use whichever is easier for a particular problem. Heisenberg utilized matrix algebra for his mechanics instead of the differential equations that had been used by everyone else since their invention by Newton and Leibnitz. In ordinary arithmetic $4 \times 6$ is the same as $6 \times 4$; both are 24. In matrix algebra the order of multiplication affects the results; frequently the product $A \times B$ is not equal to $B \times A$. The difference between the two answers is very important in matrix algebra and is called the *commutator*. In Heisenberg's theory the laws of nature appear as specifications of the value of the commutator for various pairs of quantities. For example, the commutator for the quantities describing position and momentum must be equal to the Planck constant $h$ divided by $2\pi$ times the square root of $-1$.

Quantum mechanics can be applied to the motion of planets, but for large objects quantum mechanics yields the same results as classical mechanics. Conversely, relativity theory is applied when quantum mechanics is used for small objects. Any quantum mechanical equation to be completely general must be "invariant under the Lorentz transformation." This means that due consideration has been given to variation of mass with velocity and similar relativistic effects. In fact, the extreme accuracy of quantum mechanical predictions constitutes the most convincing evidence that the ideas of relativity must be contained in some form in all future theories.

What is the current situation in microphysics? Quantum mechanics has been so successful with the behavior of the electronic parts of the atom that it is also being used in attempts to construct a model of the nucleus of the atom. Currently the nucleus is studied chiefly by throwing things at it and observing the splash. The things thrown are chiefly hydrogen nuclei or helium nuclei, and the throwing machines are the cyclotrons and other accelerators of the nuclear laboratories. The splash consists of large or small pieces of the nucleus. Much can be inferred from the mass, speed, and direction of these pieces.

Suppose that it is desired to study the carbon nucleus by bombarding a thin layer of paraffin with helium nuclei. The procedure may be compared to a study of the structure of watches by bombarding the state of Utah with golf balls. If the people of Utah distribute themselves uniformly and wear one watch apiece there will be about one watch every ½ mi. This analogy shows that it takes a lot of golf balls to hit a watch at all, and that the golf balls must be very high speed in order to knock a watch apart. The pieces of watches that land on adjacent states after the bombardment are measured for mass, direction, and speed. From these results the theorists are busy trying to construct models of all makes of watches.

Volumes of experimental results have been gathered, and the situation with the nucleus now is very much as it was with the atomic electrons in 1910. The world awaits a new Bohr to develop a

theory of the nucleus. This new theory will, as usual, include the successful parts of previous theories so that relativity and quantum mechanics will presumably be seen as special aspects of a more general concept.

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### Cow Moose and Calf

*The picture for this month's cover was taken by D. S. Rawson of the University of Saskatchewan at the Narrows of Waskesiu Lake in the Prince Albert National Park in the wooded area of northern Saskatchewan. Dr. Rawson describes the incident as follows: "I was busy with studies of fresh-water biology and fisheries of the lake when the unique opportunity to get this photograph presented itself. I first heard splashing at the water's edge and then saw the cow moose following the shore line on the opposite side of the Narrows, which is about 100 yards across. Assuming that the cow and calf would swim across at the narrowest point, I stationed myself accordingly, with my Zeiss camera and was gratified to find that they swam directly toward me. As they swam across the Narrows, the cow turned back repeatedly to see that the little fellow was all right. I took other pictures showing the calf with only its head out of water. The present exposure was made at a distance of about 50 feet. The sky was overcast and the light rather dull, but I was able to silhouette the animals against the lake as background. The ungainly outline of the cow moose and the amazing duplication of its appearance by the tiny calf seem to give the picture a very amusing and touching quality. I might add that the calf, although certainly no more than 1 week old, was quite an efficient swimmer."*

# City Neighborhood and Village

RICHARD NEUTRA

*Mr. Neutra, who has designed many public buildings, residences, and housing projects, was also the architect of the communities of Channel Heights, San Pedro, California, and Avion Village, near Dallas, Texas. He has been a consultant to various state and national governments on the design of rural schools, health centers, and hospitals and has lectured at many universities in the United States and abroad.*

OBSERVATIONAL curiosity, supplemented by analytic skill, is the basis of the scientific approach. It must have been in solitude like that of a shepherd in the hills, unengaged in dialectics, that man began quietly to watch phenomena both on the green earth and in the starry sky until he finally advanced to the stage of observing reactions following the prearrangements of a laboratory experiment.

*City planning*, on the other hand, occurs in a highly dialectic atmosphere, whether it is discussed in commissions set up by legislative bodies or by a dictator in directive conversation with his appointees. New aspirations, new anxieties, and new defenses against communal breakdowns, all caused by new urgencies, may be the motives for action. But in spite of the avowed newness of the situation, historical precedents, often painfully unrelated to the case at hand, seem to interfere with both the discussion and the action.

Out of such a muddled, confused cluster of circumstances must emerge the planning for the physical setting of a community, probably one of the most significant aspects of human living that is under man's control. I have on another occasion expressed hopes and suggested ideas for articulating a promising approach toward the handling of a communal entity by planners in a scientific age [*Survival through Design* (Oxford Univ. Press, New York, 1954)]. This article is intended merely to invite and engage the interest of scientifically trained persons in the pressing business of community design, where systematic help is so seriously needed. I wish particularly to deal here with the romantic inconsistency of using the village as a paradigm for an elementary unit in the greater urban scene. Sociologists could give invaluable aid toward clarifying our problem and cleansing it from admixtures of idyllic ideology and mistakenly borrowed or willfully misappropriated patterns.

The neighborhood in a city such as Venice, Vienna, or Bangkok is extremely helpful for redeeming sheer urban bigness. Face-to-face grouping around a Venetian campo with the shrine of a patron saint, a Buddhist temple on a Siamese canal, a parish church in an urban community—each has been recognized as momentous by social psychologists, and all these groupings precede by thousands of years our current and often frustrated attempts at planning or renewing our cities.

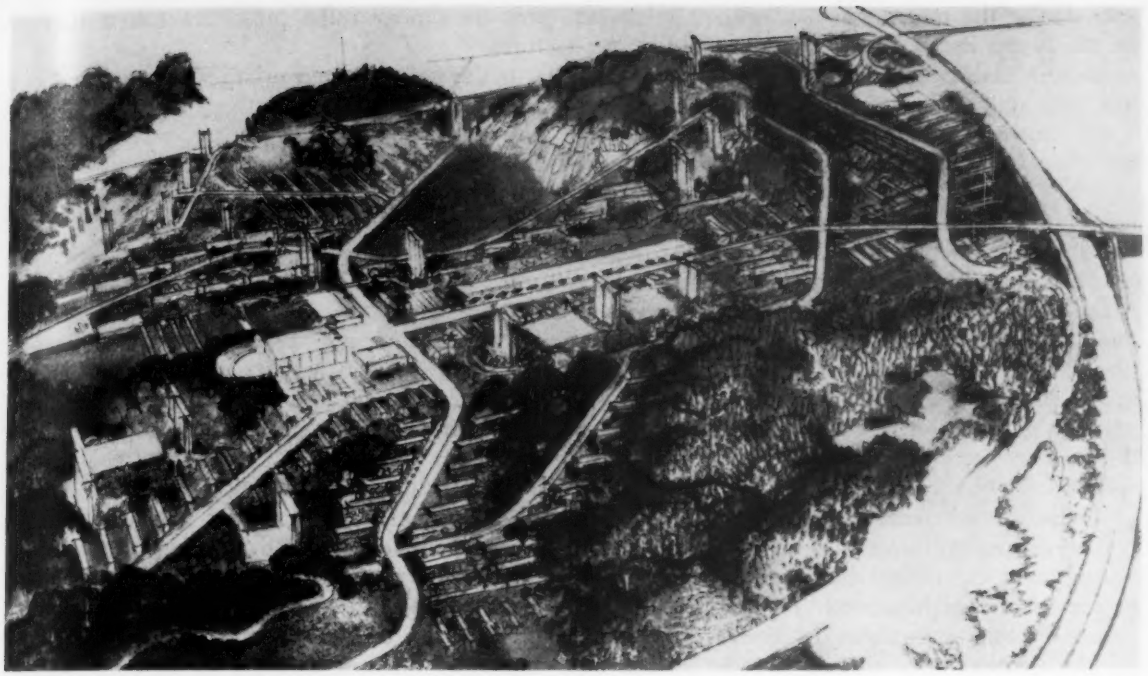
The result of the romantic approach is that a suburban neighborhood looks like a village, carries a name, and has an architectural façade reminiscent of a village.

A city planner may occasionally have had the chance to start from scratch when commissioned by Alexander the Great, General Oglethorpe, William Penn, or even within the framework of postwar British legislation; but as a rule the planner is called in to help an ailing organism, a patient throbbing with fever, languishing with asthma, or paralyzed in some members of his body. Like the practitioner of the medical art, the city planner is no scientist, but the two are similar because the scientific equipment of both is extremely necessary, and the attitudes of both must be mellowed by good, convincing, and comforting bedside manners. The manners should not and cannot substitute for the systematics of science; yet intuitive and political procedures largely govern the planner's practice.

The planner has some scientific interests and background and acts as an "applied" socioeconomist, in spite of all his suffusion with ready artistry, which chafes at the bit about scientific patience without date and caution without bias. Deadlines and biases are threatening the soundness of capital improvement programs.

An urban neighborhood is never a laboratory experiment. It must be studied in the field over long periods of habituation and interferences, with other neighborhoods as control groups to check against; it is never like an original village, a self-dependent unit with an economic and mental balance of its own.

For the village it is characteristic that it is



Elysian Park Heights. Over-all airview of the new community, which in fact is an articulated neighborhood within a metropolitan area. It is accessible from two freeways and surrounded by existing wooded hills like a village community.

helpless against strong impacts from the outside and hardly knows or finds good counsel against these impacts, either in its organization or in its citizenry. To be successfully defensive, a village has to grow into a town, as even the smallest villages do in Kwantung, China. But a circumvallated little town is still more of a stranger to a city neighborhood than is a village.

Ralph L. Beals has pointed out that in a village homogeneity prevails, and that most people share skills and knowledge. In addition, a city neighborhood of today is far removed from a company town of occupational uniformity, such as that built by the Pullman Palace Car Company in the early 1880's, which was broken up by political action that followed socioeconomic stresses.

The usual city neighborhood today seems inconceivable as the dormitory of a fixed employment market contiguous to it. Because of the natural locomotor instinct, or drive, or related reflexive disposition of people pampered by automotive progress and common carriers, the neighborhood is simply a common anchorage for commuters who crisscross over a vast, diversified employment geography.

Could or should such a commuter's home port be camouflaged as a self-contented village? Fishermen not only sail similar barges but catch similar fish for similar marketing. The commuters drive similar cars and, before going home, pick up similar cans and frozen-food packages. But they come from dissimilar employments and rise into comparable purchasing power and economic status from different pursuits, training, and preparation.

In a village the arable land and birth and death rate must be in equilibrium; otherwise there is trouble from within. On the other hand, urban neighborhood trouble originates for the most part from sources outside the neighborhood.

The church square, the plaza, and the forum were not often focal trading centers originally: the citizenry was attracted by religious rite and sport, not by trade. A full outdoor assemblage also seems to have occurred often "outside" the town proper, where there was space; this assembly was a token of peaceful circumstances, a celebration in fact of minds relaxed from war years.

The population of Nuremberg would move out in a body to hear the contest of the guild singers at the Schmausenbug Hill, outside the fortification wall. In prehistoric Machu Picchu, in Peru, or in Mayan Chicheniza, people got together on an inner free space carefully spared from the dense building area; probably such green areas were there before the era of commercial conglomeration and were therefore not inspired by it. Much later, and typically, the Merceria, the trade street of Venice, ran up to the Piazza di San Marco, but

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*City planning*, on the other hand, occurs in a highly dialectic atmosphere, whether it is discussed in commissions set up by legislative bodies or by a dictator in directive conversation with his appointees. New aspirations, new anxieties, and new defenses against communal breakdowns, all caused by new urgencies, may be the motives for action. But in spite of the avowed newness of the situation, historical precedents, often painfully unrelated to the case at hand, seem to interfere with both the discussion and the action.

Out of such a muddled, confused cluster of circumstances must emerge the planning for the physical setting of a community, probably one of the most significant aspects of human living that is under man's control. I have on another occasion expressed hopes and suggested ideas for articulating a promising approach toward the handling of a communal entity by planners in a scientific age [*Survival through Design* (Oxford Univ. Press, New York, 1954)]. This article is intended merely to invite and engage the interest of scientifically trained persons in the pressing business of community design, where systematic help is so seriously needed. I wish particularly to deal here with the romantic inconsistency of using the village as a paradigm for an elementary unit in the greater urban scene. Sociologists could give invaluable aid toward clarifying our problem and cleansing it from admixtures of idyllic ideology and mistakenly borrowed or willfully misappropriated patterns.

The neighborhood in a city such as Venice, Vienna, or Bangkok is extremely helpful for redeeming sheer urban bigness. Face-to-face grouping around a Venetian campo with the shrine of a patron saint, a Buddhist temple on a Siamese canal, a parish church in an urban community—each has been recognized as momentous by social psychologists, and all these groupings precede by thousands of years our current and often frustrated attempts at planning or renewing our cities.

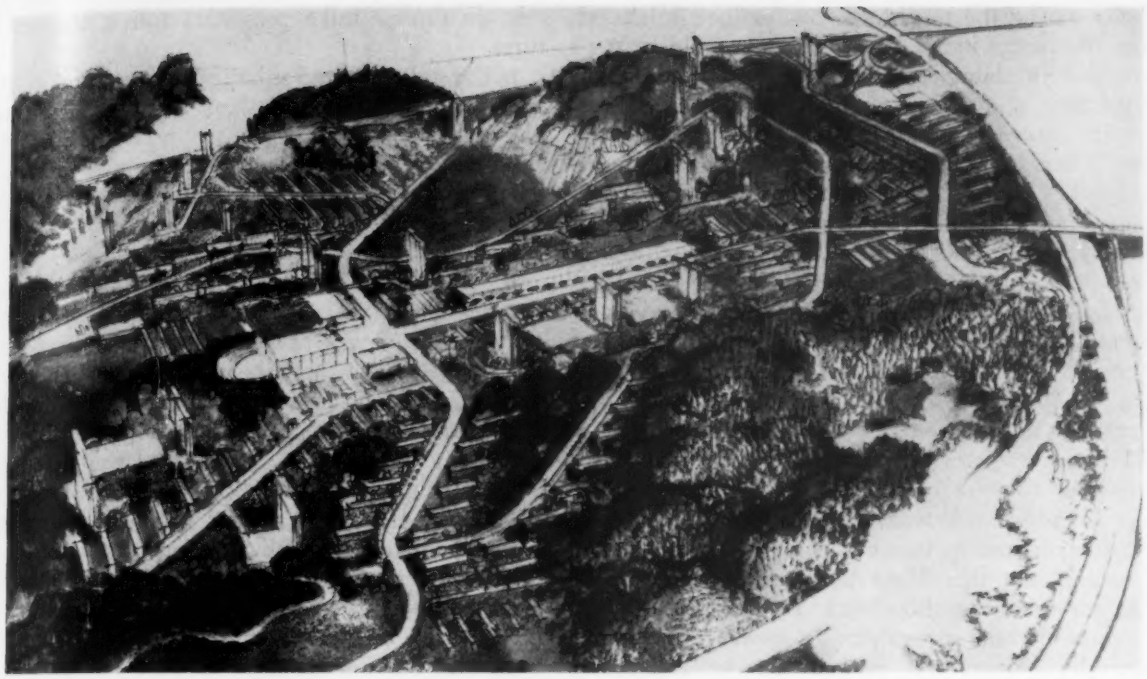
The result of the romantic approach is that a suburban neighborhood looks like a village, carries a name, and has an architectural façade reminiscent of a village.

A city planner may occasionally have had the chance to start from scratch when commissioned by Alexander the Great, General Oglethorpe, William Penn, or even within the framework of postwar British legislation; but as a rule the planner is called in to help an ailing organism, a patient throbbing with fever, languishing with asthma, or paralyzed in some members of his body. Like the practitioner of the medical art, the city planner is no scientist, but the two are similar because the scientific equipment of both is extremely necessary, and the attitudes of both must be mellowed by good, convincing, and comforting bedside manners. The manners should not and cannot substitute for the systematics of science; yet intuitive and political procedures largely govern the planner's practice.

The planner has some scientific interests and background and acts as an "applied" socioeconomist, in spite of all his suffusion with ready artistry, which chafes at the bit about scientific patience without date and caution without bias. Deadlines and biases are threatening the soundness of capital improvement programs.

An urban neighborhood is never a laboratory experiment. It must be studied in the field over long periods of habituation and interferences, with other neighborhoods as control groups to check against; it is never like an original village, a self-dependent unit with an economic and mental balance of its own.

For the village it is characteristic that it is



Elysian Park Heights. Over-all airview of the new community, which in fact is an articulated neighborhood within a metropolitan area. It is accessible from two freeways and surrounded by existing wooded hills like a village community.

helpless against strong impacts from the outside and hardly knows or finds good counsel against these impacts, either in its organization or in its citizenry. To be successfully defensive, a village has to grow into a town, as even the smallest villages do in Kwantung, China. But a circumvallated little town is still more of a stranger to a city neighborhood than is a village.

Ralph L. Beals has pointed out that in a village homogeneity prevails, and that most people share skills and knowledge. In addition, a city neighborhood of today is far removed from a company town of occupational uniformity, such as that built by the Pullman Palace Car Company in the early 1880's, which was broken up by political action that followed socioeconomic stresses.

The usual city neighborhood today seems inconceivable as the dormitory of a fixed employment market contiguous to it. Because of the natural locomotor instinct, or drive, or related reflexive disposition of people pampered by automotive progress and common carriers, the neighborhood is simply a common anchorage for commuters who crisscross over a vast, diversified employment geography.

Could or should such a commuter's home port be camouflaged as a self-contented village? Fishermen not only sail similar barges but catch similar fish for similar marketing. The commuters drive similar cars and, before going home, pick up similar cans and frozen-food packages. But they come from dissimilar employments and rise into comparable purchasing power and economic status from different pursuits, training, and preparation.

In a village the arable land and birth and death rate must be in equilibrium; otherwise there is trouble from within. On the other hand, urban neighborhood trouble originates for the most part from sources outside the neighborhood.

The church square, the plaza, and the forum were not often focal trading centers originally: the citizenry was attracted by religious rite and sport, not by trade. A full outdoor assemblage also seems to have occurred often "outside" the town proper, where there was space; this assembly was a token of peaceful circumstances, a celebration in fact of minds relaxed from war years.

The population of Nuremberg would move out in a body to hear the contest of the guild singers at the Schmausenbug Hill, outside the fortification wall. In prehistoric Machu Picchu, in Peru, or in Mayan Chicheniza, people got together on an inner free space carefully spared from the dense building area; probably such green areas were there before the era of commercial conglomeration and were therefore not inspired by it. Much later, and typically, the Merceria, the trade street of Venice, ran up to the Piazza di San Marco, but

only during the tourist era has business infringed on the piazza itself. At any rate, it would be precarious to claim that the civic and ritual center has quite uniformly a commercial origin.

In contrast, our false village, the made-up suburban neighborhood, often has far-scattered churches, each with contiguous parking areas, but none infringing on the other. Yet its "village center" is where the area grocery market and branch of the downtown department store are situated.

Emigration may destroy family ties in a village and thus the backbone of the village itself. Emigration is a daily event in the urban neighborhood, and we must accept this, for it is not a matter growing out of the soil but one of transportation; it is the result of our modern chance to live detached from our working places.

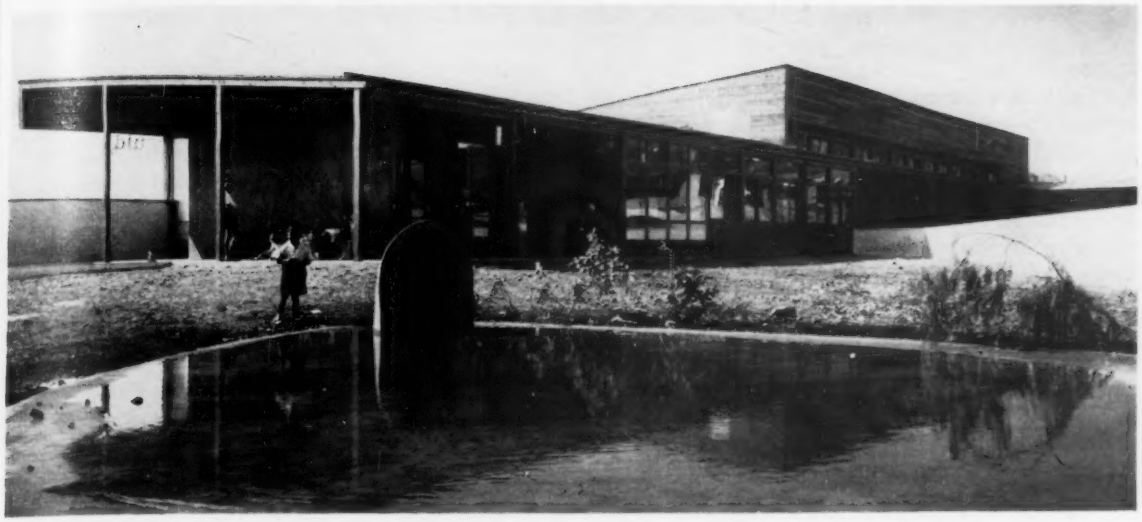
When women from a village leave farm or household and go into service or trade in a neighboring town, the village dies, but it may rise again as an urban neighborhood. In the process new values become prominent in newly conditioned minds. Spontaneous, established cooperation begins to be replaced by organization. The voluntary construction crew and fire-extinguishing team are replaced by municipal establishments or by service businesses. Individuals are watched less and conduct their businesses independently, except that they honor identical parking meters and willy-nilly tolerate similar radio programs and motion pictures.

Is the industrialized urban scene the product of a changed mentality or perhaps its cause? The embarrassing chicken-or-egg question can be stricken from the questionnaire, but the circumstances must be properly interpreted and understood in order to improve on them by plan.

And plan we must, for the tremendous energies and quantities of today leave us no time to follow the historical precedent of muddling through. Perhaps our current upset is not more radical, but it is more speedy than the revolutionary changes that took place when food gatherers first crowded into villages because, with newly invented implements, they could scratch and seed the earth to bear and support a manifold population. That no planning board had to act in such severe situations is sufficiently explained by the gradualness of that prehistoric evolution. Volumes, velocities, and negotiated energies released and consumed are so progressively different from what surrounded past humanity that the example of slow but sure adjustment holds water no longer.

Fortunately, the social sciences will have a tendency to observe more sharply and to predict more accurately in coming decades. There are a thousand and one reasons for articulation of the post-Victorian magalopolis into biologically and

Channel Heights. Openness between the different buildings gives a feeling of spaciousness, somewhat as it does in a certain type of rural community.



Nursery with spray pool in foreground becomes a center of interest and activity, like the village pond used in common by the geese, ducks, and children of the villagers.

psychologically digestible and manageable parcels. Smaller would-be metropolises have a comparable problem. It will be helped neither by false ruralization, as in some new British towns without cohesion, nor by a false "village character" quickly concocted by developers who get the nod from planning commissions for their streets with cowpath curvature.

A science is wanted, or at least its lively development toward happy application is wanted, in order to prevent our being overtaken by the destructiveness of incoherent progress. Its patent pills, although well advertised, may need to be checked by a systematic food and drug act. Their saccharine coatings may be more than just nauseating. Survival by biological adjustment to the habitat with which we tinker so fast and so badly is no longer open to us. It must come through design, responsibly aided by scientific method. I invite constructive hints, suggestions, and the cooperation of persons active in the sciences contiguous to the pursuit of planning.

*I should like to mention one case where the artist—quite unknowingly—has been able to provide valuable data for science. The clay from which the Greek potter made his beautiful vases more than 2000 years ago always contained some magnetic oxide of iron. At a certain stage of the cooling, after firing, the iron particles are very susceptible to the action of magnetic forces, and orient themselves in the direction of the earth's magnetic field. The direction of this magnetization was fixed permanently when the vase cooled and since we know the vase must have been always in a vertical position during the firing, the scientific man can find the direction of this magnetization and thus fix the inclination or 'dip' of the earth's magnetic field at the time and for the place where the vase was made. By this curious observation we have been able to extend our knowledge of the secular variations in the earth's magnetic field to a remote epoch more than 2000 years before the importance of such measurements was recognized.*—E. RUTHERFORD (1932).

# BOOK REVIEWS

**The Earth as a Planet.** vol. II of *The Solar System.* Gerard P. Kuiper, Ed., Univ. of Chicago Press, Chicago, 1954. xvii + 751 pp. Illus. $12.50.

*The Earth as a Planet* is the second volume in a four-volume series on the solar system now in preparation under the editorship of G. P. Kuiper of the Yerkes Observatory, University of Chicago. It is an excellent book that sets itself the unique task of acquainting the astronomer—and, for that matter, anyone else who should be interested—with the researches, mostly in fields bordering on astronomy, of which he should be aware before embarking upon the study and interpretation of phenomena on planets other than our earth. The authors of the 15 chapters—whose names read like a section from a who's who in the earth sciences, each writing about his specialty—present a panoramic view of such beauty that this volume becomes one of the most compelling books to read. It is written in the spirit of a handbook, but I found it one of the most fascinating volumes to browse in, since it carries the reader from questions of the earth's deep interior to the problems of the crust and mountain building, to the ever-challenging mysteries of oceanography, and out into the thin realm of our atmosphere and beyond.

The opening chapters by Harold Spencer Jones and Harold Jeffreys deal with the dimensions and rotation of the earth and the dynamics of the earth-moon system. It is very helpful to have the not-too-accessible information in these two fields summarized conveniently in one place. Chapter 3, by Edward Bullard, is on the interior of the earth. In Chapters 4 and 5, respectively, J. Tuzo Wilson discusses the development and structure of the earth's crust and Brian Mason its geochemistry. Chapter 6 is a very readable one by H. U. Sverdrup on oceanography.

The earth's atmosphere in its various aspects is the subject of Chapters 7–13. The first chapter in this group is by Horace R. Byers on the atmosphere up to 30 kilometers, and it should serve to bring many readers up to date about new developments in interpretation of atmospheric circulation. It is followed by E. Hutchinson's excellent chapter on the biochemistry of the terrestrial atmosphere—of great usefulness to all who are interested in problems of life in other worlds—and by a comprehensive chapter on the absorption spectrum of the earth's atmosphere, written by Leo Goldberg. The remaining four chapters in this group deal with the atmosphere mostly above 30 kilometers. Fred L. Whipple discusses densities, pressures, and temperatures derived from meteor and rocket data; J. W. Chamberlain and A. B. Meinel, the spectra of the night sky, twilight, and aurorae; D. R. Bates, the physics of the upper atmosphere; and M. Nicolet, dynamic effects in the high atmosphere. Two brief chapters conclude the volume, the first by Clyde T. Holliday on the earth as seen from outside the atmosphere (with some amazingly beautiful photographs made from high-altitude rockets), the second by André Danjon on the albedo, color, and polarization of the earth; the latter is in part a plea for thorough studies of the earthshine on the moon.

All told, this is a first-rate book that deserves to be read by astronomers of all varieties. *The Earth as a Planet* should also prove of great interest to anyone who is curious about our earth, its interior, its crust and oceans, and the mysteries of the atmosphere from its base to its very top.

BART J. BOK

*Harvard College Observatory*

**Fundamentals of Electrical Engineering.** Based on the rationalized MKS system of units. Edward Hughes. Longmans, Green, London–New York, 1954. xiv + 470 pp. Illus. $2.50.

This volume is a sequel to *Principles of Electricity in MKS Units* by Morley and Hughes and, in the words of the author, it

> . . . covers the electrical engineering syllabuses of the Third Year Course for the Ordinary National Certificate in Electrical Engineering, the first year course for an Engineering degree and the Intermediate examinations in "Electrical Engineering Practice" of the City and Guilds of London Institute.

This indicates the intended use of the book and serves to clarify the differences between this textbook and our own textbooks on electrical engineering.

The book roughly covers the same material that the average American university power major covers up to about the end of his junior year, but with considerably different emphasis and depth of treatment. For instance, circuit problems are given a briefer and more elementary treatment than is customary in the United States, and the complex-number notation is introduced only briefly at the end of the book. There is a correspondingly greater emphasis on other topics, such as electric and magnetic fields, computation of inductance and capacitance, transformers, d-c and a-c machines, and illumination. Electronics is treated briefly in a single chapter.

The treatment of transformers and a-c machines will be particularly novel to American readers since it is done without the use of complex numbers. This gives the book a rather old-fashioned flavor. In looking over these chapters, I have the feeling that the old-fashioned way has its merits and that the present, standard American approach is not necessarily the best. The chapter on illumination is a particularly good and concise treatment.

The book is lucidly and very carefully written. The author has very meticulously carried through his intention to use the MKS rationalized system of units throughout. Furthermore, the sequence of topics is logical and the definitions are clearly and carefully

stated. Although frequent reference is made to *Principles of Electricity in MKS Units*, this book stands by itself very well. It has about the right proportion of worked-out examples and a large number of problems. These factors make it excellent for self-study and as a reference for both teacher and student.

I regret that this volume is not readily usable in our own universities. We have a great need for books as conscientiously written as this one, particularly on the elementary level. Far too many of our books have only half converted to the MKS system.

R. C. Retherford

*Department of Electrical Engineering,*
*University of Wisconsin*

**Needed Research in Health and Medical Care.** A biosocial approach. Cecil G. Sheps and Eugene E. Taylor. Univ. of North Carolina Press, Chapel Hill, 1954. ix + 216 pp. $5.

The title of this work could be read in either one of two ways and both with equal warrant; that is, *Needed: Research in Health and Medical Care*, or, as it runs, *Needed Research in Health and Medical Care*. The text strongly reinforces the first version, and, in a lesser measure, fulfills the promise of the second. The book has a secondary title—a biosocial approach. This approach is to health and medical care. This work is difficult to summarize, although it is easy to describe.

In September 1952, a seminar, with the same title as this book, was held at Chapel Hill under the auspices of the University of North Carolina. There were 47 participants, one-half of whom were from the health and social-science faculties of the University. The visitors' half included representatives from the many disciplines in the biosocial conglomerate. Although the seminar was conducted as a meeting of minds for free discussion, it was preceded by a 3-month period of preparation during which many of the participants submitted texts for distribution among their confreres. The projected deliberations were organized under four headings: "Social physiology," "Social epidemiology," "Social science research in health," and "The administrative field." The transactions were worked over and summarized, reported, and interpreted by Sheps and Taylor who profess to be solely responsible for the choice and editing of the excerpts, for the arrangement of the material, and for the added comments. They have produced a well-integrated and readable book. The enterprise was evidently brave; its results are commendable.

And yet the reader is likely to end up, quite as the seminar participants did, inspired by its potentialities and troubled by its obvious difficulties. The underlying thesis appears to be that the union of the biological with the social sciences would yield superior insight into the etiologies of health and disease and superior plans for providing medical services and care. All the participants seemingly subscribed to the proposition *in general*. Difficulties, however, became evident as soon as an actual union of thought and knowledge was attempted. Some doubted that the time was ripe for extensive collaboration by biology and social science. Others questioned the warrant and validity of a specific designation of "biologic" and "social" and what the order of relationships of the one to the other might be. Definitions deemed basic by some were actively challenged by others, as, for example, those given of health. Yet these divergencies of opinion were not without an underlying commonality. They attested to the validity and significance of the effort to cross-illuminate the data of one field with those of the other. This is different from attempting a *union* of biology and the social sciences.

The book is provocative and stimulating. Yet it seems to be off on a false tangent. Its basic thesis, as that of the seminar, is misleading. It promises a something and then postulates—all we need is to discover how that something is best to be achieved. It takes some of its essential premises uncritically for granted. It does not critically assess either medicine or sociology; it rather accepts them as they are. But they might be otherwise.

Indeed, some question whether anything but a radical change in the teaching and practice of medicine, a change from curative to social medicine, could provide us with adequate and competent health and medical care. Also, not a few among us feel that the social sciences are too little informed on and too ignorant of the elementary principles of biology to be sound in their orientation or meaningful to the medical sciences. One of the most telling criticisms of the seminar's orientation is embodied in a quotation from Grinker on page 147.

Nevertheless, this is a valuable work and informative in itself, and I hope it will inspire other universities to arrange for further seminars in this important field.

Iago Galdston

*New York Academy of Medicine*

**Big Dam Foolishness.** Elmer T. Peterson. Devin-Adair, New York, 1955. 224 pp. $3.50.

The title, *Big Dam Foolishness*, clearly expresses the theme of this book. It is written in an appealing, journalistic style by one who is dedicated in his conviction that the large-scale dam-building program of the Army Engineers is ineffective. Peterson has attacked the program from every conceivable angle; each chapter adds to the indictment against building large dams to combat the flood menace. It is the large dams on the plowlands rather than those in mountainous terrain that are singled out.

More than one-half of the book is devoted to this indictment. Big dams not only inundate valuable agricultural lands, silt rapidly, and thus have a short life expectancy, but they are also atomic targets in wartime. Their susceptibility to pork-barrel legislation is an unhappy fact. Without proper upstream flood control, water impounded by huge dams today will be replaced eventually by sterile sand plains in many sections of the Midwest. Replenishing nature's own reservoir is the better approach to control of floods and conservation for urban water use. The multiple-purpose

dam cannot act as a satisfactory flood-control measure and at the same time serve equally for power generation and recreational purposes.

The behavior of water after it has fallen as precipitation is considered in great detail. Two views are presented as to which is the better method of controlling water and preventing floods. One is to stop the water where it falls, the other is to construct large flood-control dams. In the presentation of arguments against big dams, much light is shed on the functioning of certain segments of the hydrologic cycle.

> "Insoak—the infiltration of water into the soil—is the greatest all-around principle yet revealed in flood control practice,"

according to Peterson. It is an effective way of controlling the flow of the large amounts of precipitation and the siltation of reservoirs. Many examples of the value of the insoak program in the State of Oklahoma are cited. This method is, in addition, much less expensive for the American taxpayer since it will utilize the natural storage capacity of the soil. Meager Congressional appropriations are among the chief reasons that hinder the upstream flood control work of the Soil Conservation Service.

The author's own emotional feeling against dams sometimes makes him overstate certain points. This is in some respects a virtue of the book. It forces the reader to think about the part that the private citizen and the farmer can play. It is very difficult for the reader to follow some of the excellent description without the benefit of meaningful maps. A person with sufficient background in the over-all problem would no doubt appreciate a listing of the sources from which many of the conclusions at the end of each chapter were drawn. Conservationists, students of government, agronomists, as well as the layman, would profit from reading this book.

ERICH F. BORDNE

*Department of Geography* and *the Conservation Program, Yale University*

**Proceedings of the First World Conference on Medical Education.** Held under the auspices of the World Medical Association, London, 1953. Hugh Clegg, Ed. Oxford Univ. Press, London–New York, 1954. xvi + 804 pp. Plate. $16.

More than 600 men and women, representing 127 faculties and 62 countries, attended this conference on medical education. The conference was sponsored by the World Medical Association, with the collaboration of the World Health Organization, the Council for International Organizations of the Medical Sciences, and the International Association of Universities.

The scope and quality of these meetings may be inferred from the names of the speakers at the plenary session and the subjects of their addresses. Lionel Whitby spoke on "The Challenge to medical education in the second half of the twentieth century," Richard Livingston on "What is education," and S. M. K. Mallick on "Medicine—a technology or a profession?" After these opening speeches the conference divided into four sections, in each of which some 20 different speakers gave prepared papers. The sections dealt with requirements for entry into medical schools, aims and content of the medical curriculum, techniques and methods of medical education, and preventive and social medicine. Summaries of these papers and the discussions that ensued were prepared by the section chairmen and rapporteurs. These summaries appear in English, French, and Spanish, and they are refreshingly competent translations. Indeed, in both arrangement and presentation, this volume as a whole is a model of discriminating choice, judicious editing, and competent good taste.

Not only the level of the papers but also the range of subjects dealt with could rightly give the sponsoring organization great satisfaction. Furthermore, the conference seems to have given pleasure to the participants because tolerance balanced zeal and open-mindedness invited candor and clarity of opinion.

No advisor of premedical students would be wasting his time if he read this volume. And most teachers in any field of medicine would profit from, as well as enjoy this noteworthy rarity—a readable report of a conference on medical education.

ALAN GREGG

*Rockefeller Foundation*

**Rocket Exploration of the Upper Atmosphere.** Special supplement (vol. 1) to the *Journal of Atmospheric and Terrestrial Physics*. R. L. F. Boyd and M. J. Seaton, Eds. Interscience, New York; Pergamon Press, London, 1954. viii + 376 pp. Illus. $11.

Early in 1945, the Allies captured a large number of unassembled V-2 rockets. They turned them over to the U.S. Ordnance Department, which in turn invited interested scientific groups to utilize the space and the load facilities (essentially the "warhead") of this missile. This farsighted decision laid the solid foundation for a rocket exploration of the upper atmosphere.

It was possible to fire 66 V-2 rockets, slightly less than 50 percent of which performed satisfactorily, that is, furnished useful experimental data. A new rocket, called *Aerobee*, was developed to replace the V-2. It became the standard rocket for scientific investigations. First fired in late 1947, it is used by all services, and more than 100 Aerobees have been launched. Since its maximum altitude is 80 mi and since certain experiments demand greater altitudes, a new rocket, called *Viking*, was developed by the Navy. This rocket has reached an altitude of 139 mi. The latest development in this field was the launching of a small, inexpensive rocket by means of a balloon, thus raising the altitude of rocket firing to about 40,000 ft. Altitudes of about 60 mi have been reached.

Rocket experimentation has proved to be very difficult, since it demands new techniques and skills not employed in experimental physics. Only a very short time is available for measurements (an Aerobee reaches maximum altitude in 3 min); the acceleration during

the boost reaches 14 g; the rocket is not stable; and roll, pitch, and yaw occur. Furthermore, the measurements have to be telemetered to the ground, received, and recorded. For these and other reasons, it is not surprising that a large number of rocket flights failed insofar as experimental results are concerned.

In the summer of 1953 a conference was held in England to discuss rocket techniques as well as results obtained by rockets or by indirect probing of the atmosphere (for example, meteor studies). The papers presented at this conference were collected and 49 are combined in this book. Since the authors have been associated with rocket instrumentation from the beginning, it is not surprising that the contents of the book are well rounded and authoritative. The range of subjects is quite impressive—namely, rocket techniques; pressure, temperature, and wind in the upper atmosphere; composition of the atmosphere; structure of the inosphere; solar radiation, especially in the UV region, which becomes available at higher altitudes; geometric variations; and cosmic radiation. Some laboratory measurements and theoretical studies related to the rocket experiments are also reported.

Naturally such a collection of papers cannot cover the whole field as completely as one author would do. There are some omissions and some duplications; for example, in describing the historical aspect and details of the rocket types. The positive aspect, however, is the fact that the man who performed an experiment describes it in his own terms, thus avoiding misunderstandings or omissions of essential details. The book is so organized that both the casual reader and the serious research worker can use it to advantage. It is well printed, and unusually well illustrated, but unfortunately a subject index is lacking. Thus, the book will be a handy reference in the new but very active field of rocketry.

RUDOLF B. PENNDORF
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*Air Force Cambridge Research Center*

**Introduction to Modern Algebra and Matrix Theory.** Ross A. Beaumont and Richard W. Ball. Rinehart, New York, 1954. xii + 331 pp. $6.

This is a textbook designed for the dual purpose of providing material for a one-semester course in matrix theory and a two-semester course in introductory modern algebra at the advanced undergraduate or possibly beginning graduate level. In their exposition, the authors consistently cushion their discussion of abstract mathematical systems with a detailed examination of models that should be familiar to the student.

The exposition of matrix theory in Chapters I–III, VII, and VIII begins with the algebra of matrices over the field of complex numbers. This is followed by the theory of determinants. Then, in order to systematize the discussion of the standard canonical forms for matrices, the authors describe successively the notions of a group $G$ of transformations of a set $M$, the equivalence relationship induced in $M$ by $G$, and a canonical set of elements in $M$ relative to $G$. The first application of these ideas culminates in the determination of a canonical set for $m$ by $n$ matrices over a number field under equivalence and of its role in solving a system of linear equations. In Chapter III, basic properties of vector spaces of $n$-tuples and linear mappings of such spaces, together with their representation by matrices, are obtained. A rational canonical form under equivalence for matrices with polynomial entries and the Cayley-Hamilton theorem appear in Chapter VII. The theory of matrices is concluded in Chapter VIII with a discussion of the reduction of symmetric matrices by congruence transformations, of real symmetric matrices by orthogonal transformations, and of Hermitian matrices by conjunctive, as well as unitary, transformations. Thus, only the study of simplifications in a matrix under similarity transformations is omitted from the traditional list.

The remainder of the book deals with the structure of various algebraic systems. Chapter IV on groups discusses homomorphisms, direct products, and defining relationships for groups. Chapter V on number systems outlines the successive specializations of the concept of ring that lead to a characterization of the real numbers as a particular type of ordered field. Chapter VI is concerned with polynomial rings and properties of fields and their extensions.

ROBERT R. STOLL
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**The Origin of Russia.** Henryk Paszkiewicz. Philosophical Library, New York, 1954. xii + 556 pp. Illus. $10.

The author of this scholarly work reviews many controversies and interpretations of available sources of our information about the peoples living in the Dnieper and Volga river systems from the 9th to the 14th centuries. He is thoroughly familiar with the sources and their interpretation by scholars. By an exhaustive, minute, and methodical analysis of the chronicles of the period, he demonstrates their essential reliability in fundametal matters. National and Soviet ideological bias in interpretation of the sources is countered by a comparative study of all the available sources that tend to corroborate one another and to prove their essential reliability.

Paszkiewicz bolsters the traditional view about Norman and Finnish influences in the building of the Kievan and Muscovite states. His interpretation of the changing meaning of the term *Rus* over the centuries appears to be supported by the evidence of the sources.

This work of meticulous scholarship is an excellent compendium of the work done by scholars in this area and will serve both scholars and laymen with the best information on the subject to date.

There are 13 appendixes of more than 100 pages, dealing with controversial topics, such as the question of the reliability of "The tale of the raid of Igor." An extensive bibliography of 50 pages, two maps, genealogical tables, and an index are included.

FRANK T. NOWAK
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**The Passenger Pigeon.** Its natural history and extinction. A. W. Schorger. Univ. of Wisconsin Press, Madison, 1955. xxiii + 424 pp. Illus. + plates. $7.50.

It has been the purpose of the author of this book, during the 20 years spent in its preparation, to bring together, in compact form, a digest or a compilation of the more important of the widely scattered records bearing on the natural history and extinction of the passenger pigeon, *Ectopistes migratorius* (Linn.). Something of the general scope of the work may be gained by enumeration of its more important subdivisions. These include such subject headings as early accounts, behavioral characteristics, food, movements, roosts, nesting, utilization, methods of capture, decrease and extinction, description, anatomy, physiology, nomenclature, distribution, migration, and late records. There is also an evaluation of illustrations plus references, notes, and an index.

It was no easy task to reconstruct the life-history of an extinct species in the face of a large and sometimes contradictory literature, since much is now beyond absolute proof, and there were many lacunae and unanswered questions. In addition to interviews and correspondence, much toil and time had to be devoted to a search of the literature, notably old newspapers, in the library of the State Historical Society of Wisconsin and elsewhere. These old newspapers proved helpful in providing much more information than could be found in scientific and sporting periodicals, and the job has been well done.

On the whole, the story of the complete extinction of a species that was once so numerous seems almost incredible. Yet, here it is, carefully and fully documented. A particularly horrible and striking example of the long-continued waste of our natural resources! To the cheek of the most blatant and hardened anti-conservationist, it is enough to bring the blush of shame.

J. S. WADE

*U. S. Department of Agriculture*

**A History of Birds.** James Fisher. Houghton Mifflin, Boston; Riverside Press, Cambridge, 1954. x + 205 pp. Illus. $3.75.

This book reviews a good sample of the present-day knowledge concerning distribution, classification, evolution, and numbers of birds. It is, in fact, a revision of the author's earlier book, *Birds as Animals,* published in 1939, but the new version does not deal with breeding behavior, habitat relationships, migration, and certain other topics. They were evidently omitted in order to obtain a small book, and Fisher declares that these subjects will be dealt with in a second volume.

The title properly emphasizes that generous brush sweeps of historical background are provided for all the topics. Indeed, the first three chapters review the roots and foundations of ornithology, in old manuscripts and then in early print, first in Britain and then in the rest of the world. The remaining chapters deal with systematics, distribution, paleontology, speciation, numbers, and man's relationships with birds. In these chapters, recent information and modern views are discussed according to their historical roots and development. This is less true of the chapter on speciation, which, by this book's presentation, seems *really* to begin historically with Mayr (1942). References to antecedents are inadequate. For example, Grinnell wrote about geographic speciation in 1904, 1914, and 1928.

Categorical or sweeping statements are rather frequent. One of the more stunning is "that classification [of birds] is probably more difficult than that of any other group of animals" (p. 31). Readers may also disagree with the author on grounds other than scientific. For example, Fisher subscribes enthusiastically to Elsa G. Allen's favorable appraisal of Alexander Wilson as an ornithologist, but I do not see that to push Wilson up we have to pull Audubon down. Fisher's comments (p. 68) on the supposedly unattractive features of Audubon's work are not supported by the facts of history, and they merely reveal his preference for simple representationalist art.

I find the chapters on paleontology and changing bird numbers more interesting and worth while than the rest of the book, the former because compact reviews of knowledge concerning bird fossils are few, the latter because the subject of change is presented with less ornithocentric bias than all else in the book. It is a book about birds, true, but if as must be the case, the information is cast in terms of biological problems, the results are often oddly misleading. For example, the comments of one ornithologist admitting lack of data on interspecific competition in European birds (p. 109) is taken seriously to indicate lack of competition, when well-studied examples in other animal groups certainly support a biologically more realistic viewpoint which is that competition occurs among species that overlap in their use of any resource. Further research must determine when and how such overlap becomes significant. Another example of the results of this ornithocentric bias is the discussion (p. 111) of the Lincoln index as of 1930 and its application to birds then, when this is really the Petersen index whose applicability to fish was suggested by this well-known Danish biologist in 1896.

The style of writing is very good, and the text, in the main, is well organized. Much that is discussed is fairly accessible elsewhere. More illustrations would have helped, and certain blocks of information, such as the enumeration of bird families on pages 59–61, should have been tabulated.

*A History of Birds* is a book for the intelligent and college-trained bird enthusiast and for the bird lover who enjoys reading or working in the more scholarly phases of his hobby. Although the preface states that the book was "designed for university students," I would prefer to have university students read in Huxley, Mayr, Dobzhansky, Simpson, Allee *et al.,* Elton, and several well-selected review papers, where the facts are presented less breezily and as stones in foundations of biological thinking rather than as birdlore.

By now this review may seem rather critical. If so,

two comments come to mind. The first is that a book like Fisher's should be reviewed from the standpoint of a biologist rather than from that of an ornithologist. This, I believe, is what Fisher would want, as the title of his earlier book indicates. Nevertheless, in this book, the balance between birds and the common denominators of concept and thought about animals is anything but a balance!

The second comment is based on an observation that the author himself makes on page 141, where he states that "in Britain one bird book is now published on an average every week." Such an output arouses one's skepticism, and on a year-round basis it strikes me as being 20 to 30 too many.

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**The Bomb, Survival and You.** Protection for people, buildings, equipment. Fred N. Severud and Anthony F. Merrill. Reinhold, New York, 1954. 264 pp. Illus. + plates. $5.95.

This book describes in popular style the effects of atomic weapons that would cause damage to buildings and injure or kill people. It is divided into three parts: (i) a discussion of the phenomena attending the detonation of an atomic or hydrogen weapon; (ii) a discussion of the effects of the atomic weapons on the buildings at Hiroshima and Nagasaki, and (iii) a section that includes a number of suggestions for strengthening existing buildings and for designing new buildings with a greater amount of blast resistance than normal and methods of securing protection for people.

This book would probably be valuable to the building owner who wishes to understand the effects of atomic weapons and the steps that he can take to decrease the risk of damage to his plant or building. On the other hand, because the book contains a number of misconceptions, it is important that the technical reader be aware that a certain amount of the material is not accurate. With reference to the latter, my criticisms are as follows: (i) The phenomenon of blast loading of buildings, both windowless and fenestrated, is inadequately and sometimes inaccurately described. Drag loading (or that portion of loading on a building due to the blast winds) is very much underestimated. (ii) The overturning and sliding effect on buildings and shelters caused by the blast forces is not always considered. The suggested reinforced concrete shelter for factories completely ignores this dangerous mode of failure. Some discussion of the methods of reinforcing buildings also seemingly ignores this effect. (iii) The discussions of blast and radiation are so general that they are of little value to anyone but the casual reader.

On the other hand, the book has merit in the following matters: (i) The ideas with regard to the strengthening of buildings in order to resist blast are, in general, worth consideration by the building owner. (ii) The inclusion of the generally unavailable Hiroshima and Nagasaki data will be of assistance to the engineering and architectural professions.

Perhaps the authors are not to be criticized too harshly for their inadequate portrayal of the nature of blast forces on buildings. Not much authentic information is available to the general public. However, there are publications that should be much more valuable than this one for a critical understanding of the subject.

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**The History and Conquest of Common Diseases.** Walter R. Bett, Ed. Univ. of Oklahoma Press, Norman, 1954, ix + 334 pp. $4.

For the benefit of patients ("mainly") and of the medical profession, 18 American and British scientists have reported on the developments of medicine since ancient times. In 17 chapters they deal with acute communicable diseases, influenza, pneumonia, tuberculosis, rheumatism, arthritis, heart diseases, nephritis, diseases of Waldeyer's ring, venereal diseases, rickets, endocrinological disturbances, gallstones, appendicitis, epilepsy, cancer, and malingering.

It is an impressive program, heavily taxing the editor's and the contributors' ability to winnow the right topics, to divide the space properly, and to present essentials. It was a formidable task to condense the tremendous amount of available information to 282 pages fortified with 52 pages of a glossary of medical terms (for the patients), references, and an index. To a large extent the execution of the task was good. Some parts are fascinating reading, but others, however, are overloaded with details that are forgotten before the page has been turned.

In the history of human diseases, infections have played a preeminent role. It is, therefore, proper to start the book with them in order to exemplify as thoroughly as possible the evolution of ideas and of the practical approach and to describe the conquest of diseases. Since the book's title states that it is the history of "common diseases" and not of *some* common diseases, one is surprised to miss such afflictions as typhus, typhoid, cholera, dysentery, and malaria, while diphtheria and scarlet fever occupy 35 pages, and measles, chicken pox, and mumps take up five pages. In the comprehensive history of diphtheria, the statements on tracheotomy are unsatisfactory. If Baillou and Severino are mentioned, there is no reason to pass over in silence Fabricius ab Aquapendente (16th century), the only man since Antyllus (2nd century) who made a lasting contribution that enabled physicians, in an emergency, to carry out this life-saving operation with only a sharp knife as an instrument.

It was courageous to include several matters that are far from being solved and are still in a state of confusion and require more intensive search. For such chapters, selection of essential topics is more difficult and necessarily arbitrary. Opinions about these chapters,

especially the one on cancer, will, therefore, be divided. Of the 26 pages devoted to cancer, the lion's share is given to experimental research, and many details not even remotely connected with the problem of cancer in man are included; on the other hand, cancer in man is treated rather superficially. The whole history of *surgical* endeavors and achievements from Hippocrates to Lister is told in about 220 words, and surgical cancer therapy from 1860 to 1953 occupies exactly zero lines! The sketch of cancer edipemiology, scanty as it is, requires some corrections. For example, arsenical cancer was recognized 67 years (Paris, 1820) earlier than is stated by the author. His argument against the bilharzial cancer relationship is immaterial. Decisive only is whether or not bladder cancer is more frequent in Egypt than in populations free of bilharziasis (and of aniline dye factories).

In a new edition some space should be given to common mental diseases and to the impact of changing standards of living upon medicine.

SIGISMUND PELLER
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**Instrumental Methods of Chemical Analysis.** Galen W. Ewing. McGraw-Hill, New York–London, 1954. x + 434 pp. Illus. $6.50.

The development of many improved procedures and new techniques for separating and/or measuring desired constituents troubles many teachers of quantitative chemical analysis who wish to go beyond traditional gravimetry and titrimetry. To meet the problem, several books on so-called instrumental methods have appeared. This one adds another to the list.

Part I (345 pp.) comprises 19 selected "instrumental" sections, the choices ranging from conductimetry, through analysis of gases, to ion exchange. One wonders what is meant by "instrumental," for these three examples illustrate, respectively, a method of measurement, the analysis of materials in a particular physical state, and a process of separation. Most of the sections have a brief exposition of basic theory, typical apparatus, and representative applications, together with supplementary numerical problems. The presentation seems adequate for advanced undergraduates and beginning graduates, for whom the book is intended.

Part II (57 pp.) contains laboratory directions for 33 exercises selected to illustrate various principles and apparatus described in part I. Although brief, the directions seem clear and workable. Presumably, not more than the usual laboratory period is needed for each exercise. These exercises are largely conventional procedures; several of them have been standard methods for decades.

Many physical chemists would claim for their domain the determinations of the solubility of a salt (exercise 1) and the ionization constant of an indicator (exercise 21). Although neither volumetry nor densimetry is discussed as such in part I, exercises 29 and 31 employ these methods of measurement.

I question this book chiefly on the usage of terms and on the implied over-all viewpoint on methods as a whole. To elaborate on the matter would require space not available here. Perhaps what I have in mind may be illustrated by questioning more specifically what is meant by the word *instrumental.*

First of all, the term is not defined. The sidehead on page 6 indicates that separation is not part of analysis. If it is not, the title of the book would then imply that analysis must be measurement. Yet at least four of the 19 sections in part I—electrodeposition, extraction, chromatography, and ion exchange—are separation processes. Six of the laboratory exercises concern primarily, or entirely, separation processes and not measurement. One gets the impression, too, that instrumental excludes gravimetry (together with my fine Ainsworth balance) and titrimetry. However, exercises 1–4 and 7 employ titrimetric measurement, with only electric indication of end-points. I performed exercise 27 in 1912, and my students performed it in 1954, as an example of a volatilization-absorption *gravimetric* method. Does the long-used evolution-absorption apparatus employed for separating the carbon dioxide make the method instrumental? Similarly, is not exercise 30 (fat in nuts) an extraction-gravimetric method? In 1914, Blasdale included essentially the same procedure to illustrate this type of method.

This criticism is not of the author personally. Rather it is to direct attention again to the confusion resulting from the failure of analysts to agree on consistent terms, definitions, and usages. For example, what is meant by endings such as *-al, -imetry, -metric, -tion, -ance,* and *-ivity*? A rapidly expanding literature makes some standardization increasingly important.

Incidentally, the spelling "absorptiometry" is not consistent with "reflectometry," a long-used term, nor do the spellings "burette" and "pipette" conform to A.C.S. recommendations.

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**Hopi Ethics: A Theoretical Analysis.** Richard B. Brandt. Univ. of Chicago Press, Chicago, 1954. x + 398 pp. $7.50.

This volume is, in part, a report of research conducted among the Hopi Indians at intervals between 1946 and 1948. Brandt's objective was to gather data concerning the actual beliefs and ethical attitudes of one native group and to demonstrate its relevance to ethical theory. His basic assumption is that primitive societies provide the best opportunity for observing human nature in different conditions.

The book deals with various aspects of Hopi culture, such as the structure of the conscience, the ideal personality, ethical convictions, and cultural change. A constructive section is devoted to a psychological theory of some Hopi norms. A valuable feature of the book is the citation of the questions that Brandt raised and the answers that he received. No attempt is made to conceal the deficiencies of the information gathered.

The ideal Hopi man emerges as a good family man,

industrious and thrifty, agreeable in his social relationships, peaceful, cooperative, generous, honest, and modest. Mental equanimity appears to be the most desirable personal trait, a quality that is admired as a means to individual health as well as to social and cosmic harmony. Differences in attitude between Hopi and white Americans on such subjects as personal aggression, sexual relationships, and cruelty to animals are indicated.

Of greatest interest to students of ethnological theory is Brandt's treatment of psychological theory and his explanation of Hopi ethical norms. He is critical of "historical-diffusion analysis" as well as of "functional analysis," and he regards both as inadequate for explanatory purposes. Instead, he proposes his own "psychological contemporary context theory" and two psychological principles or laws, namely, "the theorem of utility" and the "theorem of reward." Upon closer analysis, it appears that the theorem of utility simply states that acts regarded as, or believed to be, harmful are disapproved and those regarded as beneficial are approved—a principle of naturalistic ethics at least as old as Aristotle. The theorem of reward states that particular ethical attitudes are developed in a given society if their expression is socially rewarding—a thesis that hardly goes beyond Sumner's *Folkways*. The alleged explanatory and predictive value of these principles is far from evident.

The author has not taken into consideration the arguments of ethnological theorists such as Kroeber and Lowie, who long ago indicated the futility of general psychological principles as an explanation of particular ethnological facts. Brandt reintroduces the historical-cultural factor under the category of acquired beliefs and attitudes "in the contemporary context." The role of acculturation in affecting beliefs and attitudes is scarcely considered and is subsumed under "cultural change." The book is informative and interesting, but makes no significant contribution to ethnological theory in general or ethical theory in particular.

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# Books Reviewed in SCIENCE

### 6 May

*Advances in Enzymology and Related Subjects of Biochemistry*, vol. 15, F. F. Nord, Ed. (Interscience). Reviewed by H. B. Bensusan.

*Limit Distributions for Sums of Independent Random Variables*, B. V. Gnedenko and A. N. Kolmogorov (Addison-Wesley). Reviewed by C. M. Zieman.

*The Use of Stereographic Projection in Structural Geology*, F. C. Phillips (Arnold). Reviewed by J. M. Carr.

*Tropical Soils*, E. C. J. Mohr and F. A. Van Baren (Uitgeverij, Van Hoeve; Interscience). Reviewed by C. W. Thornthwaite.

*The Sun, the Sea and Tomorrow*, F. G. Walton Smith and Henry Chapin (Scribner's). Reviewed by J. W. Hedgpeth.

*Abhandlungen aus der Sowjetischen Physik*, folge III, Robert Rompe, Ed. (Kultur und Fortschritt). Reviewed by W. C. Dunlap, Jr.

*Modern Aspects of pH*, James Small (Van Nostrand). Reviewed by R. G. Bates.

### 13 May

*Faune de France*, vol. 58, *Mollusques Opisthobranches*, A. Pruvot-Fol (Lechevalier). Reviewed by W. J. Clench.

*Grignard Reactions of Nonmetallic Substances*, M. S. Kharasch and Otto Reinmuth (Prentice-Hall). Reviewed by R. G. Bossert.

*Liver Injury*, F. W. Hoffbauer, Ed. (Josiah Macy, Jr. Foundation). Reviewed by I. N. Dubin.

*Oral Pathology*, Kurt H. Thoma (Mosby). Reviewed by H. B. G. Robinson.

*The Foundation of Statistics*, Leonard J. Savage (Wiley; Chapman & Hall). Reviewed by S. Weiss.

*Colorimetric Methods of Analysis*, vol. IV, Foster Dee Snell and Cornelia T. Snell (Van Nostrand; Macmillan). Reviewed by E. Allen.

*Wasserbestimmung mit Karl-Fischer-Losung*, Ernst Eberius (Verlag Chemie).

### 20 May

*Antibodies and Embryos*, F. W. Rogers Brambell, W. A. Hemmings, and M. Henderson (Athlone Press; de Graff). Reviewed by J. D. Boyd.

*The Physics of Viruses*, Ernest C. Pollard (Academic Press). Reviewed by G. S. Stent.

*Heat Conduction*, Leonard R. Ingersoll, Otto J. Zobel, and Alfred C. Ingersoll (Univ. of Wisconsin Press). Reviewed by R. L. Pigford.

*Manufacture and Application of Lubricating Greases*, C. J. Boner (Reinhold). Reviewed by H. R. Baker.

### 27 May

*Progress in Biophysics and Biophysical Chemistry*, vol. 4, A. V. Butler and J. T. Randall, Eds. (Academic Press; Pergamon Press). Reviewed by H. B. Bensusan.

*Chemistry of Lichen Substances*, Yasuhiko Asahina and Shoji Shibata (Japan Society for the Promotion of Science; order from Maruzen, Tokyo). Reviewed by L. E. Harris.

*Introduction to Theoretical Mechanics*, Robert A. Becker (McGraw-Hill). Reviewed by N. H. Frank.

*The Application of Results of Research*, Vera Connell, Ed. (Academic Press; Butterworths). Reviewed by G. B. Johnson.

*Psychological Testing*, Anne Anastasi (Macmillan). Reviewed by J. W. Gustad.

*Renal Function*, Stanley E. Bradley, Ed. (Josiah Macy, Jr. Foundation). Reviewed by A. M. Fishberg.

*Diagnostic Cytologique du Cancer Génital chez la Femme*, Raymond Bourg, Claude Gompel, and Jean-Paul Pundel (Masson). Reviewed by C. Hoch-Ligeti.

*Isotopic Gas Analysis for Biochemists*, R. F. Glascock Academic Press). Reviewed by B. M. Tolbert.

*Transactions of the Symposium on Fluid Mechanics and Computing*, Garrett Birkhoff, K. O. Friedrichs, and T. E. Sterne, Eds. (Interscience). Reviewed by J. Rothstein.

# New Books

***Quantitative Analysis.*** Albert Frederick Daggett and William Buell Meldrum. Heath, Boston, 1955. 470 pp. $5.

***Receptors and Sensory Perception.*** A discussion of aims, means, and results of electrophysiological research into the process of reception. Ragnar Granit. Yale Univ. Press, New Haven, 1955. 369 pp. $5.

***Science and the Human Imagination.*** Aspects of the history and logic of physical science. Mary B. Hesse. Philosophical Library, New York, 1955. 171 pp. $3.75.

***Mathematics for the Chemist.*** Mathematical analysis for chemists, physicists, and chemical engineers. G. J. Kynch. Academic Press, New York; Butterworths, London, 1955. 356 pp. $4.80.

***Elements of Servomechanism Theory.*** George J. Thaler. McGraw-Hill, New York–London, 1955. 282 pp. $7.50.

***Methods of Biochemical Analysis.*** vol. II. David Glick, Ed. Interscience, New York–London, 1955. 470 pp. $9.50.

***The Prevalence of People.*** Marston Bates. Scribner's, New York, 1955. 283 pp. $3.95.

***Analytical Cytology: Methods for Studying Cellular Form and Function.*** Robert C. Mellors, Ed. Blakiston Div., McGraw-Hill, New York–London, 1955. 511 pp. $15.

***An Introduction to Cell and Tissue Culture.*** The Staff. Burgess, Minneapolis, 1955. 123 pp. Paper, $4.

***A Histology of the Body Tissues with a Consideration of Their Functions.*** Margaret Gillison. Livingstone, Edinburgh, Scotland, 1950. 220 pp. 15s.

***Doctors in the Sky.*** The story of the Aero Medical Association. Robert J. Benford. Thomas, Springfield, Ill., 1955. xv + 326 pp. Illus. $8.75.

***Floods.*** William G. Hoyt and Walter B. Langbein. Princeton Univ. Press, Princeton, 1955. 469 pp. $7.50.

***Foundations of Quantum Theory.*** A study in continuity and symmetry. Alfred Lande. Yale Univ. Press, New Haven, 1955. 106 pp. $4.

***Fundamentals of Radiobiology.*** Z. M. Bacq and Peter Alexander. Academic Press, New York; Butterworths, London, 1955. 389 pp. $6.50.

***Ion Exchange and Adsorption Agents in Medicine.*** The concept of intestinal bionomics. Gustav J. Martin. Little, Brown, Boston–Toronto, 1955. 333 pp. $7.50.

***Plane Trigonometry.*** C. R. Wylie. McGraw-Hill, New York–London, 1955. 381 pp. $4.

***Biochemistry and Physiology of Protozoa.*** vol. II. S. H. Hunter and Andre Lwoff, Eds. Academic Press, New York, 1955. 388 pp. $9.

***Dairy Cattle: Selection, Feeding, and Management.*** William Wodin Yapp and William Barbour Nevens. Wiley, New York and Chapman & Hall, London, ed. 4, 1955. 420 pp. $4.76.

***The American School in Transition.*** William E. Drake. Prentice-Hall, New York, 1955. 624 pp.

***Rutin and Related Flavonoids.*** John Q. Griffith, Charles F. Krewson, and Joseph Naghski. Mack, Easton, Pa., 1955. 275 pp.

***The Zoological Record.*** Records of the zoological literature relating chiefly to the year 1952. vol. 89. G. Burder Stratton, Ed. Zoological Society, London, 1955. 19 sections.

***Soviet Civilization.*** Corliss Lamont. Philosophical Library, New York, ed. 2, 1955. 447 pp. $5.

***Semimicro Qualitative Analysis.*** Frank J. Welcher and Richard B. Hahn. Van Nostrand, New York–London, 1955. 497 pp. College, $6.50; reference, $8.

***Apes, Angels, and Victorians.*** The story of Darwin, Huxley, and evolution. William Irvine. McGraw-Hill, New York–London, 1955. 399 pp. $5.

***The Colloid Chemistry of Silica and Silicates.*** Ralph K. Iler. Cornell Univ. Press, Ithaca, N. Y., 1955. 324 pp. $5.50.

***The Non-Human Primates and Human Evolution.*** James A. Cavan, Ed. Wayne Univ. Press, Detroit, 1955. 134 pp. $3.50.

***Paracas Fabrics and Nazca Needlework, 3rd Century B. C.–3rd Century A. D.*** The Textile Museum Catalogue Raisonne. Junius Bird and Louisa Bellinger. National Pub., Washington, D. C., 1954. 126 pp.

***Molecular Vibrations.*** The theory of infrared and raman vibrational spectra. E. Bright Wilson, Jr., J. C. Decius, and Paul C. Cross. McGraw-Hill, New York–London, 1955. 388 pp. $8.50.

***Radiobiology Symposium, 1954.*** Proceedings of the symposium held at Liege, Aug.–Sept. 1954. Z. M. Bacq and Peter Alexander, Eds. Academic Press, New York; Butterworths, London, 1955. 362 pp. $9.80.

***Science and Its Background.*** H. D. Anthony. Macmillan, London and St. Martin's Press, New York, ed. 2, 1954. 336 pp. $4.

***Descriptive College Physics.*** Harvey E. White. Van Nostrand, New York; Macmillan, London, 1955. 485 pp. $5.75.

***The Rocket Pioneers on the Road to Space.*** Beryl Williams and Samuel Epstein. Messner, New York, 1955. 241 pp. $3.75.

***Psychology in Industry.*** A psychological approach to industrial problems. Norman R. F. Maier. Houghton Mifflin, Boston, ed. 2, 1955. 678 pp. $5.50.

***Automobile Workers and the American Dream.*** Ely Chinoy. Doubleday, Garden City, N. Y., 1955. 139 pp. $3.

***The Piltdown Forgery.*** J. S. Weiner. Oxford Univ. Press, New York–London, 1955. 214 pp. $3.50.

***Electrolyte Solutions:*** The measurement and interpretation of conductance, chemical potential and diffusion in solutions of simple electrolytes. R. A. Robinson and R. H. Stokes. Academic Press, New York; Butterworths, London, 1955. 512 pp. $9.50.

***Poliomyelitis.*** World Health Organization, Palais des Nations, Geneva, 1955. 408 pp. Cloth, $8.

***College Algebra.*** Paul R. Rider. Macmillan, New York, rev. ed., 1955. 397 pp. $4.

***Ciba Foundation Symposium on Chemistry and Biology of Pteridines.*** G. E. W. Wolstenholme and Margaret P. Cameron, Eds. Little, Brown, Boston, 1954. 425 pp. $8.

***Nomography and Empirical Equations.*** Dale S. Davis. Reinhold, New York 22, 1955. 236 pp. $6.75.

***Numerical Methods.*** Andrew D. Booth. Academic Press, New York; Butterworths, London, 1955. 195 pp. $6.

***Men, Microscopes, and Living Things.*** Katherine B. Shippen. Viking Press, New York, 1955. 192 pp. $3.

***General Chemistry.*** L. E. Steiner and J. A. Campbell. Macmillan, New York, 1955. 673 pp. $6.50.

# ASSOCIATION AFFAIRS

## Preliminary Announcement of Atlanta Meeting

The 122nd meeting of the American Association for the Advancement of Science, the annual meeting for the year 1955, will be held in Atlanta, Ga., 26–31 Dec. This will be the first time that the AAAS has met in the South since the 1941 meeting in Dallas—and the first time in the Southeast since the Richmond meeting of 1938. In the intervening years, the Association's annual convention has increased in size but, fortunately, the physical facilities of Atlanta have also increased so that it is again possible to meet in this part of the nation. There have been eight AAAS meetings in the South: Charleston, S.C., 1850; Nashville, 1877; New Orleans, 1905; Atlanta, 1913; Nashville, 1927; New Orleans, 1931; Richmond, Va., 1938; and Dallas, 1941. The Association returns to Atlanta after an interval of 42 years.

The four decades since the first Atlanta meeting in 1913 have witnessed a veritable revolution in nearly every aspect of science and society. Agriculture has become much more diversified and on an increasingly scientific basis, and great industries have multiplied and developed. A marked increase in the production of natural gas and electric power, added to abundant natural resources of water and minerals, have resulted in commensurate increases in original industries, such as steel, sulfur, fertilizers, and naval stores, and in a host of new developments. Many of the nation's largest and most modern oil refineries, pulp and paper mills, chemical plants, and textile mills, processing both natural and synthetic fibers, are in the southern states.

There have been advances in medicine and public health. Southern schools, colleges, and universities have expanded and improved to keep pace with the demands for well-trained graduates. The volume of research has steadily increased. In recent years, great atomic energy projects at Oak Ridge, Tenn., and elsewhere have begun to have a profound effect on southern science and technology.

*Atomic energy.* It is logical that this 122nd meeting of the Association will focus the nation's attention on the South's present status and future potentials and will bring to the region the newest developments in all fields of science. One instance of this will be a four-session symposium, "Atomic energy and agriculture," sponsored jointly by the Oak Ridge Institute of Nuclear Studies and the Association. This symposium, as planned by a committee headed by Cyril L. Comar, principal scientist, medical division, ORINS, will comprise a critical and realistic survey of the use of radioisotopes in the agricultural sciences—including unsolved problems, anomalies, and potentials.

The four parts of the symposium are as follows: (i) Soil-plant relationships—chairman, Nathan S. Hall, biology and medicine division, U.S. Atomic Energy Commission. Included: soil chemistry and fertility, soil testing, micronutrients, soil physics, and soil-root relationships. (ii) Plant metabolism—chairman, Harold B. Tukey, Michigan State University. Included: foliar absorption, translocation, photosynthesis, nitrogen metabolism, and plant regulators. (iii) Animal metabolism—chairman, Homer Patrick, University of Tennessee. Included: micronutrient metabolism, macronutrient metabolism, lactation and hormones, and amino acids-sulfur metabolism. (iv) Food sterilization—chairmen, C. G. King, Nutrition Foundation, and B. F. Trum, Veterinary Corps, U.S. Army, assigned to AEC, Oak Ridge. Included: bases of radiation sterilization, isotope availability and use, design of facilities, biochemical problems, acceptance of radiated foods, present status and feasibility of radiation sterilization. The speakers will be recognized experts from all parts of the nation. The entire program, planned for a large audience, is coordinated with the research conference on "Use of isotopes in agriculture" to be held 12–14 Jan. 1956 at Michigan State University under the auspices of the Council of Participating Institutions of the Argonne National Laboratory.

*International Geophysical Year* [*Science* **119**, 569 (1954)]. The International Geophysical Year—really 18 months, 1 July 1957 to 31 Dec. 1958—will transcend the previous International Polar Years of 1882–83 and 1932–33 in that it covers the whole globe, includes many more scientific disciplines, and will have the concerted efforts of the scientific organization of some 40 nations. The AAAS Atlanta meeting will include the first, and probably only, program open to the general scientific public on the scope of the scientific programs of the U.S. National Committee for the IGY. The three sessions of the IGY symposium (Joseph Kaplan and Hugh Odishaw as program chairmen), sponsored jointly by the AGU, NRC, NSF, and the AAAS, will outline the problems and observations to be made in cosmic rays and solar terrestrial effects; ionospheric physics, aurora and airglow; geomagnetism; meteorology; oceanography; glaciology; and seismology. Speakers on these phases will come from various parts of the country.

*Crisis in Science Education.* At its meeting on 8 May, the recently established Committee on AAAS Meetings (Leonard Carmichael, Bernard D. Davis, John E. Ivey, Jr., Harry C. Kelly, and Howard M. Phillips) agreed that AAAS meetings should include and emphasize programs that are of importance to science as a whole. The committee decided that the Atlanta meeting should include consideration of the serious situation in the United States today of too few college students electing majors and graduate work in the sciences and engineering and the related problem of the growing shortage of qualified science teachers at both the high-school and college levels.

The problem is of such general significance that a special session—for the AAAS as a whole—will be held on the morning of 29 Dec. Speakers of national eminence will survey the steps that must be taken, and the contributions that can be made, by national organ-

izations, federal and state agencies, industry, and educational institutions. AAAS sections will not hold sessions that morning, and the participating societies will be asked to clear it also, if at all possible, so that all may be able to attend. All AAAS affiliates and interested agencies and institutions are invited to send delegates to this session. AAAS Council meeting II on 30 Dec. will be largely devoted to what organized science can do as a major contribution to this emergency.

*Participating societies.* The annual national meetings of the following will be held with the AAAS:

Academy Conference
American Association of Clinical Chemists
American Nature Study Society
American Phytopathological Society
American Society of Parasitologists
National Association for Research in Science Teaching
National Association of Biology Teachers
Society for the Advancement of General Systems Theory
Society of Systematic Zoology

The following societies have scheduled regional meetings:

American Academy of Forensic Sciences
American Geophysical Union, Southeastern Section
American Association of Hospital Consultants
American Meteorological Society
American Physiological Society
American Psychiatric Association
American Society of Plant Physiologists, Southern Section
Association of Southeastern Biologists
Botanical Society of America, Southeastern Section
Ecological Society of America
Herpetologists League
National Academy of Economics and Political Science
National Association of Science Writers
National Science Teachers Association
National Speleological Society
Society for the Advancement of Criminology
Society for Research in Child Development

Other organizations which have planned special programs are

AAAS Cooperative Committee on the Teaching of Science and Mathematics
Alpha Chi Sigma
Alpha Epsilon Delta
Conference on Scientific Editorial Problems
Conference on Scientific Manpower
National Geographic Society
Scientific Research Society of America
Sigma Pi Sigma
Society of the Sigma Xi
United Chapters of Phi Beta Kappa

*Center of the meeting.* The recently enlarged Atlanta Municipal Auditorium will be the focal point of the meeting. Located within a few blocks of the downtown hotels, it will house (i) the AAAS Main Registration and Information Center; (ii) the Visible Directory of Registrants; (iii) the AAAS Science Theatre; (iv) the Annual Exposition of Science and Industry; (v) a number of sessions; and (vi) the Biologists' Smoker (open to all registrants), 29 Dec. Immediately across the street are the classroom buildings of the Atlanta Division of the University of Georgia where there will be a lounge and where many other sessions will be held.

AAAS headquarters hotel will be the much enlarged Dinkler Plaza. Other "downtown" hotels—all of them close together and near the auditorium—are the Atlantan, Georgia, Hampton, Henry Grady, Imperial, Jefferson, Peachtree on Peachtree, and Piedmont. Some of these will house sessions and, collectively, they afford a substantial number of sleeping rooms at a wide range of rates.

A second center of the meeting will be the Hotel Atlanta Biltmore area about 1½ miles due north of the downtown center—readily reached by trackless trolleys along Peachtree Street. Other hotels close by are the Cox-Carlton, Georgian Terrace, and Peachtree Manor. There will be sessions in the Biltmore and on the nearby campus of the Georgia Institute of Technology.

The facilities of Atlanta University, 1 mile west of the downtown hotels, have also been offered to the Association, and several sessions—notably the AAAS presidential address by Warren Weaver and the reception that follows—will be held here 28 Dec. Special buses will facilitate traffic between the hotels and Atlanta University that evening and daily between the hotels and the Auditorium.

The parasitologists will have an afternoon of demonstrations in the biological laboratories at Emory University, and an open house for visiting biologists may be scheduled.

*Housing.* Housing accommodations are adequate, but, as in all cities, single rooms are relatively scarce and double rooms used for single occupancy cost more. Sharing a room with a colleague or friend is strongly recommended. It is anticipated that dormitory units at both Georgia Tech and Atlanta University will be available. Detailed housing information and a coupon for room reservations will begin to appear in *Science* and *The Scientific Monthly* in July, at which time the headquarters of each section and participating society will be announced.

*Advance registration.* Advance registrants will receive the General Program-Directory early in December by first class mail. Coupons will appear in AAAS journals beginning in July.

## The Programs

### A—Mathematics

Details of the program of Section A are not yet available, but it is probable that the sessions will come early or late within the period 26–31 Dec., so that it will be possible for mathematicians to attend also the meetings of the mathematical societies at Houston.

### B—Physics

Section B (J. H. Howey, program chairman) will have sessions for invited papers on pure and applied physics—for example, radiation measurements—on graduate research programs, and on the teaching of physics. The Physicists' Dinner will be sponsored jointly with *Sigma Pi Sigma,* which will also arrange the symposium, "The role of physics in premedical education," cosponsored by Alpha Epsilon Delta. The *American Meteorological Society* (Seymour Hess, program chairman) will hold its 142nd national meetings at Atlanta and will also cosponsor the AGU program. In addition to arranging the afore-mentioned four-session symposium, "Atomic energy and agriculture," the *Oak Ridge Institute of Nuclear Studies* will cosponsor the symposium, "Some peaceful uses of atomic energy" of the National Academy of Economics and Political Science.

### C—Chemistry

Section C (Robert S. Ingols, program chairman) will have three or four sessions for contributed papers, 27, 28, 31 Dec.; a two-session symposium, "Effect of chemical agents on biological organisms"—not a catalog of reactions but an attempt to understand the mechanisms of the responses, 28 Dec.; a symposium, "Sedimentary kaolins along the southeastern fall line" including origin, processing, mineralogical studies, uses in paper industry, ceramics, and so on, 29 Dec.; a two-session symposium, "Radiation chemistry," 30 Dec.; and a vice-presidential address by Ingols and Chemists' Dinner, 29 Dec.

*Alpha Chi Sigma* will sponsor a Chemists' Luncheon and it is anticipated that the *American Chemical Society, Georgia Chapter* will hold its December meeting with the AAAS. The *American Association of Clinical Chemists* (Albert Edward Sobel, program chairman) has arranged a symposium, "Recent concepts in clinical chemistry," and a dinner, 26 Dec.; and two sessions for contributed papers in clinical chemistry, 27 Dec.

### D—Astronomy

Section D's program, in process of arrangement, will include a vice-presidential address by Gerald M. Clemence.

### E—Geology and Geography

Section E (Robert L. Nichols, secretary) will have concurrent sessions for contributed papers in geology and geography, one or more symposia, a smoker, and a vice-presidential address by Wallace W. Atwood, Jr.—with appropriate portions of its program cosponsored by the *Geological Society of America* and the *Association of American Geographers, Southeastern Division.* The *National Geographic Society* will have its usual excellent lecture and accompanying film. The *National Speleological Society* is planning a session for contributed papers, 27 Dec., and may have an additional joint program with the *Georgia Minerals Society.*

### F—Zoological Sciences

The program of Section F (J. Gordon Carlson, program chairman) includes sessions for contributed papers in all fields other than systematic zoology and parasitology, 26, 27 Dec.; demonstrations, a Zoologists' Dinner, and vice-presidential address by Dr. Carlson, 29 Dec.; and a two-session symposium, "Formation and early development of the embryo," organized by R. C. von Borstel with Albert Tyler as chairman, 27 Dec. Egg formation, fertilization, and various physiological and cytological aspects will be considered. Speakers include E. J. Dornfeld, Oregon State; W. S. Vincent, State University of New York Upstate Medical Center; C. B. Metz, Florida State; A. Monroy, University of Palermo, Italy; J. R. Gregg, Columbia University; W. E. Berg, University of California, Berkeley; R. C. von Borstel, Oak Ridge National Laboratory; and Albert Tyler, California Institute of Technology. Section F is cosponsoring the symposia, "The species concept" of the Association of Southeastern Biologists, "Applications of immunochemistry to biological research" of the Society of General Physiologists, and "Atomic energy and agriculture," part III.

The national annual meeting of the *American Society of Parasitologists* (A. C. Walton, secretary) comprises five sessions for contributed papers, 28–30 Dec.; and a presidential address, annual luncheon, a business meeting, and demonstrations, 29 Dec. The *Herpetologists League* (James A. Fowler, program chairman) plans three sessions for papers, 28, 29 Dec., and an all-day field trip, 30 Dec. The national annual meeting of the *Society of Systematic Zoology,* following the pattern of former meetings with the Association, will have sessions for contributed papers, one or more symposia or panels, evening lectures, and a business meeting. A feature will be the annual exhibition of the SSZ Library of books and monographs.

### FG—Biological Sciences

The special program of the *Association of Southeastern Biologists* (Mary Esther Gaulden, program chairman) will include a meeting of the executive committee, 27 Dec.; a breakfast, 28 Dec.; and three symposia. The first of these, "The species concept," of broad interest to all biologists, is jointly sponsored by AAAS Sections F and G and the ASB and will be cosponsored by a number of other societies. Its two sessions, 29 Dec., will present the points of view of the taxonomist, paleontologist, bacteriologist, protozoologist, parasitologist, ecologist, biochemist, cytologist, and geneticist. The society will cosponsor "Formation and early development of the embryo," outlined under Section F, and "Applications of immunochemistry to biological research" of the *Society of General Physiologists.* This latter symposium, organized by Norman G. Anderson, with H. R. Wolfe as chairman, which will be held on 28 Dec., will include antibody production, preparation of cellular antigens, agar diffusion techniques, and applications to specific problems. The SGP, in addition, may have a session for contributed papers.

The *Ecological Society of America* (Eugene P. Odum, program chairman) plans a program—jointly, in part with the Botanical Society of America, Southeastern Section (Robert B. Platt, program chairman)—that will include exhibits of ecological instrumentation, of interest to both physical and biological scientists; a field trip to Stone Mountain; and sessions for contributed papers jointly with Sections F and G. The annual national meeting of the *National Association of Biology Teachers* (John P. Harrold, program chairman) begins with a business meeting, 26 Dec.; includes two joint morning sessions with the ANSS and NSTA and three afternoon sessions, 27–29 Dec.; and concludes with an all-day field trip, jointly with ANSS, 30 Dec.

**G—Botanical Sciences**

Section G (Barry Commoner, secretary) is planning a two-session symposium that will deal in an integrated fashion with the economic, technologic, physiological, and biochemical aspects of "The tobacco plant" and "The cotton plant," 27 Dec. There will be two or more sessions for contributed papers, probably jointly with the *Botanical Society of America, Southeastern Section,* 28, 29 Dec.; and a Botanists' Dinner and vice-presidential address by Lawrence R. Blinks, 29 Dec. Among the symposia that Section G will cosponsor are "Atomic energy and agriculture," and "The species concept."

The program of the annual national meeting of the *American Phytopathological Society* (Glenn S. Pound, secretary) includes three council meetings, 27 Dec.; two general business meetings, 28 and 30 Dec.; seven series of four concurrent sessions for papers, 28–30 Dec.; a symposium, "Plant pathologists can use television," 28 Dec.; and the Phytopathologists' Banquet, 29 Dec. The meeting will be held jointly with the annual meeting of the *APS, Southern Division.*

The *American Society of Plant Physiologists, Southern Section* (Aubrey W. Naylor, program chairman) is arranging a two-session symposium, "The mechanism of action of plant growth substances" that will be cosponsored by Section G.

**I—Psychology**

Section I (William D. Neff, secretary) has scheduled five sessions of invited papers on the following subjects, arranged as indicated: "The status of military psychology, 1955." Wilse B. Webb, 27 Dec.; "Recent studies of the sensory processes," John F. Hahn, and "The brain and behavior," Harlow W. Ades, 28 Dec.; "Learning," Stanford C. Erickson, and "Primate behavior," Arthur J. Riopelle, 29 Dec. The vice-presidential address by S. S. Stevens will be given 27 Dec. and there will also be sessions for contributed papers. The *Society for Research in Child Development* will hold a regional meeting at Atlanta.

**K—Social and Economic Sciences**

Section K (Donald P. Ray, secretary) will have one or more symposia centering on varying phases of the economic development of the South and probably another on political trends in the region. There will be a vice-presidential address by Conrad Taeuber. The section will cosponsor the program of Section P, Section M's symposium, "Orthopedic appliances and the economics of rehabilitation," and the symposium, "Some peaceful uses of atomic energy," of the *National Academy of Economics and Political Science,* which is also cosponsored by *Pi Gamma Mu.*

**L—History and Philosophy of Science**

Section L (Jane M. Oppenheimer, secretary) will have a full program of sessions for invited and contributed papers and a vice-presidential address by Raymond J. Seeger, "Man and science." The symposia planned are "Mathematics and biology," "The sociology of science," "Science and the humanities," and "Creativity in science," all cosponsored by appropriate AAAS sections. The *Philosophy of Science Association* will cosponsor a portion of the section's program, as also will the *Southern Society for Philosophy and Psychology.* The recently organized *Society for the Advancement of General Systems Theory* (L. von Bertalanffy, executive secretary) has scheduled two afternoon sessions for contributed papers.

**M—Engineering**

Section M (M. J. Goglia, program chairman) plans a symposium that will be of wide interest to all fields of engineering—automation. A second symposium on "Orthopedic appliances and the economics of rehabilitation," with accompanying exhibits, arranged by Eugene F. Murphy and cosponsored by Sections K and N, will be held 30 Dec.; speakers include Robert L. Bennett, Augustus Thorndike, Eugene F. Murphy, Anthony Staros, W. Frank Harmon, McCarthy Hanger, Jr., Grace M. Fraymann, and Donald H. Dabelstein.

**N—Medical Sciences**

As in previous years, Section N (S. E. Luria, program chairman) will have a four-session symposium, the participants of which will come from all parts of the nation. This year's subject, "Microbiology and medical research," scheduled for 27, 28 Dec., includes (i) "Nutrition of microörganisms," (ii) "Metabolic aspects of medical microbiology," (iii) "Radiation effects in microbiology," and (iv) "Chemotherapy." The fourth session will include the vice-presidential address of Luria, the 11th presentation of the Theobald Smith Award of Eli Lilly and Company, and the first presentation of the new AAAS-Anne Frankel Rosenthal Memorial Award for Cancer Research.

*Alpha Epsilon Delta* (Maurice L. Moore, national secretary) will have its customary annual luncheon and meeting with the AAAS, 28 Dec., with William McGlothlin of the Southern Regional Education Board speaking on "Problems of medical and dental education in the southern area." The society will cosponsor the symposium, "The role of physics in premedical education," of Sigma Pi Sigma. The *American Academy of Forensic Sciences* will have a program of in-

terest to its members and others in the medical-legal professions.

The *American Association of Hospital Consultants* (Jack Masur, program chairman), will have its usual special symposium with the AAAS. The program of the *American Psychiatric Association* (Harold E. Himwich, program chairman), will be a four-session symposium, "Physiological bases in psychiatry" on 27, 28 Dec.; the sessions—"New psychopharmacologic agents," "Mechanisms of actions in new agents," "Effects of alcohol on brain respiration and metabolism," and "Alcohol addiction"—will, in part, be a sequel to the highly successful program on psychiatry-pharmacology at the Berkeley meeting. This symposium at Atlanta will be cosponsored by Section N and the *American Physiological Society* (Fred A. Hitchcock, program chairman), which is tentatively planning a special program on the teaching of physiology.

### Nd—Dentistry

Section Nd (Joseph F. Volker, program chairman) will have two symposia, "Newer knowledge of the physiology of the salivary glands" and "Oral structures in forensic medicine" on 28 Dec., cosponsored by the *American College of Dentists,* the *American Dental Association,* and the *International Association for Dental Research, North American Division.*

### Np—Pharmacy

Section Np (John E. Christian, secretary) has scheduled seven sessions, 28–30 Dec., that will include a symposium and panel discussion on "Toxic household materials and appropriate antidotes," a specialized symposium on "Applications of nucleonics to the health professions" and contributed papers. The entire program will be cosponsored by the *American Association of Colleges of Pharmacy, American College of Apothecaries, American Pharmaceutical Association, Scientific Section,* and the *American Society of Hospital Pharmacists.*

### O—Agriculture

The section (J. Fielding Reed, program chairman) is cosponsoring the entire symposium, "Atomic energy and agriculture," section C's symposium "Effect of chemical agents on biological organisms," and section G's symposia on "The tobacco plant" and "The cotton plant."

### P—Industrial Science

Section P (H. M. Conway, Jr., program chairman) will have a two-session program, cosponsored by Section K, on "Resource development through science," which will include a regional case history of resource development—the South; specific resource studies on agriculture and land, water, minerals, and education and human resources; and a panel discussion that (i) will identify scientific approaches to the economic and industrial development of geographic areas, and (ii) will relate these specific techniques to the specific needs of the South. Section P will have its customary luncheon at which Malcolm Bryan, president, Federal Reserve Bank of Atlanta, will preside, and the retiring vice-presidential address of George L. Parkhurst will be given, on 28 Dec.

### Q—Education

Section Q (Dean A. Worcester, secretary) anticipates an unusually strong program at the Atlanta meeting, 26–30 Dec. In addition to three sessions for contributed papers, there will be a symposium, "Education of the gifted" and another session, jointly with the *International Council for Exceptional Children*; three joint sessions with the *American Educational Research Association*; a two-session symposium, "Visual efficiency" arranged by N. Franklin Stump; a business meeting and a vice-presidential address by Carter V. Good. In addition, the section, together with the NSTA, AERA, the AAAS Cooperative Committee, the NABT, and the *Central Association of Science and Mathematics Teachers,* will cosponsor the symposium, "Implications and applications of recent research in science education" arranged by George G. Mallinson for the *National Association for Research in Science Teaching* (Clarence M. Pruitt, secretary), which also will hold its annual meeting with the AAAS.

The *AAAS Cooperative Committee on the Teaching of Science and Mathematics* (John R. Mayor, program chairman) will hold a session 29 Dec. and cosponsor the AAAS program on "The crisis in science education." The regular regional meeting of the *National Science Teachers Association* (Katherine Hertzka, program chairman) with the AAAS will consist of some eight sessions, two of them jointly with the ANSS and NABT.

### X—Science in General

The annual *Academy Conference* (Leland H. Taylor, program chairman), composed of delegates and other members of the 42 academies affiliated with the Association, will hold a day of sessions. A new feature will be an Academy Information Center during the meeting period. The *American Geophysical Union* (Werner A. Baum, program chairman) will have three afternoon sessions, 27–29 Dec., to complement the three morning sessions of the International Geophysical Year, of which the AGU is a cosponsor.

The annual national meeting of the *American Nature Study Society* (Malvina Trussell, program chairman) will consist of a symposium, "Southern agriculture from 1913–1956," and social mixer, 27 Dec.; the annual banquet and presidential program—"Early naturalist explorers of the southeastern states" (illustrated) by Malvina Trussell, 29 Dec.; two joint sessions with the NABT and NSTA and a joint field trip, 30 Dec., with the NABT.

The fourth *Conference on Scientific Editorial Problems* (Marian Fineman and A. E. Tyler, cochairmen)

plans several groups of invited papers on problems in editing, technical writing, and scientific publication. The fifth *Conference on Scientific Manpower* (Thomas J. Mills, program chairman) plans two afternoon sessions, 27, 28 Dec., which will be cosponsored by the *Engineering Manpower Commission*, the *Scientific Manpower Commission*, the *National Research Council*, and the *National Science Foundation*.

The *National Association of Science Writers* (Odom Fanning, program chairman) will have its annual symposium and a business meeting with the AAAS. The annual address and award of the William Procter prize of the *Scientific Research Society of America* is scheduled for the evening of 29 Dec., following the society's joint luncheon with the *Society of the Sigma Xi* and the annual convention of RESA earlier that day. The annual address of the *Society of the Sigma Xi* will be held the evening of 27 Dec.; the 56th annual convention on the morning of 29 Dec preceding the joint luncheon with RESA. The 16th annual lecture of the *United Chapters of Phi Beta Kappa* is scheduled for the evening of 30 Dec.

RAYMOND L. TAYLOR
*Associate Administrative Secretary, AAAS*

## AAAS-Rosenthal Award for Cancer Research

The American Association for the Advancement of Science announces that, beginning this year, it will award annually the AAAS-Anne Frankel Rosenthal Memorial Award for Cancer Research. The award is supported by the Richard and Hinda Rosenthal Foundation and consists of $1000. It will be given once each year for at least 5 years for outstanding research by a scientist resident in the United States. In proposing the award, the foundation stated:

> We do not wish to exclude an outstanding advance on the more applied, or even clinical, level, but we do wish to make it quite clear that very basic pieces of research would surely qualify for primary consideration.

The board of directors of the Association has named Warren Weaver as chairman of the award committee and has invited the American Cancer Society, the National Cancer Institute, the Sloan-Kettering Institute, and the American Association for Cancer Research each to nominate one member of the committee. Richard L. Rosenthal, president of the Richard and Hinda Rosenthal Foundation, will also serve as a member of the committee. Each year this committee will nominate a recipient prior to the Association's annual meeting during the last week in December. The nomination will be formally submitted for approval by the board of directors of the Association and will be announced at the annual meeting.

The first award will be announced in December 1955 and will be for work that was completed or reported to the scientific world sometime during 1954 or 1955. Later awards will be for work completed or reported subsequent to the last previous work that received the prize.

The committee, using suggestions received from its own membership and from whatever proposals it may see fit to solicit, will consider only work that has been reasonably fully reported to the scientific community through the usual oral or printed channels, so that the work will have been subject to the usual processes of general scientific judgment regarding its validity and importance.

*The action of the investigator is periodic. He grapples with a subject of enquiry, wrestles with it, and exhausts, it may be, both himself and it for the time being. He breathes a space, and then renews the struggle in another field. Now this period of halting between the investigations is not always one of pure repose. It is often a period of doubt and discomfort—of gloom and ennui.*—JOHN TYNDALL, *Fragments of Science.*